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Waste Policy Formulation and Implementation: Recycling and Landfill

INNOVATION AND TECHNOLOGY ASSESSMENT UNIT

(International Ecotechnology Research Centre)

PhD Thesis

1994

ABSTRACT

This thesis considers recycling as one option to improve the environmental performance of industry in the UK. A systems approach is used to identify objectives and capabilities of legislative and industrial agencies and to analyse issues in the broad context of waste policy formulation and implementation which spans both constituencies.

It is shown that regulatory change to empower industrialists as decision takers is limited by a shortage of recycling infrastructure in the UK. Although well resourced firms are developing progressive waste policies in house, other firms are less well equipped to respond to regulatory pressures in a manner that is congruent with legislative objectives.

An innovative option to develop recycling facilities for construction wastes at a landfill site is assessed, considering the roles of construction firms, skip hauliers and waste managers.

An investigation is conducted into the practices employed by construction firms that influence wastes arising and likely changes to such practices. It is shown that pressures on construction firms are leading to some improvements to waste streaming that favour the recycling option.

A spatial model of landfill catchment is used to estimate the elasticity of the volume of a given waste type delivered to a landfill site with respect to prices charged at the site and competing facilities.

The option to recycle a substantial fraction of construction waste is compared with the null option of continuing to landfill waste without pre-treatment using a comparative cost benefit model. This model shows that, in the case of construction waste, benefits due to extending the working life of a landfill pit can be more significant than revenue effects for waste managers. Whether these benefits justify the costs of recycling is shown to be dependent on characteristics of particular landfill sites and on the discount rate used for assessing costs and benefits accrued over time.

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ACKNOWLEDGEMENTS

I would like to thank the following people:

Sylvia and David Greaves for making everything possible

Martyn Cordey-Hayes for his sense of perspective

Roger Seaton for showing how to make things work

Brian Hundy for his constructive advice

Ian Ward, Malcolm Robinson and Ian Barber for their support and assistance

Maureen, Rosie and Jan for their cheery encouragement

All my colleagues at INTA/IERC for their camaraderie and sympathy

The consultants who gave their time and opinions freely

The Quality Manager and his colleagues who provided useful information and insights

To Cathy

CHAPTER ONE

Recycling and Waste Management

1.1 Introduction

This thesis investigates the roles of Legislative and Regulatory Agencies, Waste Producers and Waste Managers (capitals are used to identify perspectives as stipulated on p.37) in the process of industrial Waste Policy formulation and implementation in the UK. The research conducted focuses on comparison of recycling with other waste management options. Waste issues are considered from the perspectives of each constituency to identify attributes, conditions and decision criteria which influence Waste Policy formulation and implementation for each. A conceptual model is presented which enables consideration of issues in a broader context than is apparent from any single perspective.

A first phase of research explores general implications for recycling as one option to improve the environmental performance of industry in a research framework designed to inform and develop the conceptual model of Waste Policy. Legislative and Waste Producer perspectives are investigated in order to determine relevant sets of attributes, conditions and decision criteria for each constituency. Where possible, such information is simplified and represented using modelling devices which can be applied in concert with the conceptual model of Waste Policy formulation and implementation.

A second phase of research assesses a particular option to recycle construction waste at a landfill site by:

> Investigating the particular issues faced by construction firms of the kind identified as relevant to waste in the first phase of research.
>
> Developing a waste transport model which is applied to estimate likely consequences of changes in landfill prices in terms of increased amounts of construction waste attracted for recycling purposes.
>
> Employing a model which compares financial costs and benefits of recycling construction waste at a landfill site with the null option of continuing to landfill waste without pre-treatment under various conditions (such as reduced prices to attract more construction waste).

Throughout the second phase of research, findings are considered in the context of more general issues regarding Waste Policy. This generalisation of findings is based on issues identified in the first phase of research.

The conceptual model is used in two ways;

> As a tool to focus research on relevant attributes of agencies involved in Waste Policy formulation and implementation

As a mechanism for interpreting research findings;

in terms of conceptual devices which can be used with the model to represent additional detail of the process of Waste Policy formulation and implementation

or in terms of conditions that influence the behaviour of agencies involved in the process of waste policy formulation and implementation.

The research presented in this thesis was conducted under the auspices of the SERC "Total Technology Programme". This programme seeks to improve industrial exploitation of academic resources in the UK by sponsoring research which is of direct use to industrial organisations. In this case, the research was focussed on industrial utility by developing a relationship with a client organisation (Blue Circle Waste Management Ltd - BCWM).

1.2 Blue Circle Waste Management Ltd: Background Information

Blue Circle Waste Management Limited (BCWM) is a subsidiary of Blue Circle Industries PLC. Blue Circle PLC has many interests in mineral extraction. Prior to the establishment of BCWM, the parent company leased its disused quarries to waste management firms to be managed as landfill sites. In the 1970's, a methane leak at one site caused considerable damage to local residences. The leasing firm could not afford the costs of remediation and compensation, leaving Blue Circle PLC liable for significant damages.

In the aftermath of this incident, the parent firm established a landfill division to manage landfill sites professionally and minimise the risk of such incidents recurring. This landfill division became part of BCWM, founded upon the acquisition of two established waste management companies in 1989. BCWM is now composed of three divisions:

Landfill Division established in 1984
Energy and Waste Systems Ltd (EWS) which merged with the landfill division of Blue Circle PLC in 1989 to form BCWM. EWS specialises in waste water treatment.
Basic Energy (UK) Ltd was also acquired by BCWM in 1989 and is a licensee of incinerator technology developed by Basic Environmental Engineering Inc, established in 1970 in the USA.

This research project was sponsored by BCWM. The firm provided financial support and helped to identify useful areas of research to be undertaken. The research was concerned in particular with the interests of BCWM Landfill Division.

BCWM Ltd directly manages and leases landfill sites which handle about two million tonnes of waste per annum, making it one of the largest ten firms in the landfill business.

BCWM's interest in recycling is broader than considering traditional markets such as cans, bottles and paper. From BCWM's point of view, the question of what can be recycled is governed by either the legislation in force or the market available for the end product. In the absence of current legislation to promote recycling in particular, they are interested in identifying conditions which influence the financial viability of recycling.

In the course of the research project, the particular example of recycling construction waste is identified as a suitable case study for the following reasons:

> One of BCWM's landfill sites was experiencing competition from a transfer station which recycled construction waste into materials for use at landfill sites. It is thought that a similar operation could be installed as a "front end" to other landfills operated by BCWM.
>
> The final products of the particular recycling operation are soils and hardcore for use on landfill sites. Hence information regarding final markets for materials is obtainable from BCWM.

1.3 The Landfill Industry In The UK

In the UK, between eighty and ninety percent of waste is landfilled. This high proportion (by international comparisons) is encouraged by low transport costs and an abundance of landfill sites near to urban areas making landfill a cheap option (Johnson 1990).

Two major environmental problems associated with landfill sites are:

> **Leachate:** a liquid which escapes from landfill sites carrying partially decomposed organic materials and microbes.
>
> **Landfill Gas:** a potentially explosive mixture consisting of two parts methane and one part carbon dioxide which is produced by decomposition of organic material.

Recently, strict requirements for landfill site design and prosecutions for incidents involving escape of materials from landfill have led to improved standards of landfill in the UK and have contributed to higher landfill prices.

Leachate pollution can be addressed by:

> Locating sites in areas with favourable geology (such as impermeable clay)
>
> Locating sites near to less sensitive ground waters
>
> Designing and operating sites to reduce rainwater ingress.
>
> Use of artificial impermeable liners during landfill site preparation.

Landfill gas can be contained by use of pumps to maintain a negative pressure on landfill sites enabling gases to be collected or "flared off."

The use of pumps and prevention of rainwater ingress must be balanced against maintaining good conditions in the site for anaerobic digestion of putrescible wastes. This process requires maintenance of a moist environment and low levels of oxygen (which can be sucked in by pumps).

The increased degree of containment achieved has also been accompanied by an increase in the use of landfill for disposal of hazardous materials (particularly liquid and water soluble wastes). Sites able to contain hazardous wastes are still relatively scarce and they attract such wastes from a large catchment area. This has led to concern amongst local people about increased volumes of traffic hauling hazardous materials in their area. Landfill companies opening new sites must spend considerable time and money convincing local people and Local Authorities that the site is safe and that increased traffic will not pose a risk for local residents.

Currently, landfill companies are not able to open new sites as rapidly as sites are closed. Consequentially there are trends towards

designing larger sites

extending the lifetime of existing sites (by land raising)

increasing the throughput of existing sites (and decreasing working lifetime) by increasing traffic to sites (or the size of vehicles used) or extending site opening hours

The latter trend has served to damage public confidence in the landfill industry, making planning consents harder to acquire and thereby exacerbating the cause of the trend.

The high cost of technology employed to reduce pollution problems and the high cost of preparing applications for planning consents (which can take up to two years) has pushed smaller firms out of the sector and led to consolidation by a few larger firms in the industry. This factor may also contribute to higher landfill prices.

> "These companies, often of national and international repute, will bring their own high standards of operation and expectation to bear. Whilst this should bring a degree or two of comfort, it will also have an indirect price tag"
>
> (Ward 1992 p.124).

BCWM recognise that increasing costs of landfill contribute to pressures for Waste Producers to reduce wastes arising. They are also aware that Waste Producers are adopting waste minimisation options in response to recent changes in environmental legislation and regulation. Since recycling wastes can present similar benefits in terms of waste reduction and improvement to environmental performance, BCWM want to know whether changes in conditions experienced by Waste Producers improve the viability of recycling as an alternative to landfill.

BCWM do not have interests in waste haulage, unlike other large waste management firms. Their direct customers are usually Waste Hauliers rather than Waste Producers. From BCWM's point of view, the "deliverable" from the first phase of research is "market research" into the attributes, conditions and decision criteria relevant to Waste Producers that influence the kinds and amounts of waste they produce and any benefits they may appreciate due to involvement in recycling (in comparison with sending waste to landfill sites or with adopting waste minimisation options).

1.4 Recycling as One Option in the Context of Waste Policy

The benefits of promoting recycling through Waste Policy are usually recognised in terms of its contribution to Sustainable Development. "Principle 3" of the "Rio Declaration on Environment and Development" states that;

> "The right to development must be fullfilled sa as to equitably meet development and environmental needs of present and future generations"
> (UNCED 1992 p.11)

The balance of how much to sustain and how much to develop depends on factors such as;

> How much weight is given to amenity value of natural resources
>
> Whether life to be preserved includes all life or just humans
>
> Whether Sustainable Development should encompass all future generations or the next generation only.

Whatever weighting is given to such factors in political, social and personal values of the day defines "Sustainable Development" for a given individual or social or political group. To the author's knowledge, there is no objective definition of "Sustainable Development" which has been shown to encompass its use by all interested parties.

It may be said however, that any option, which improves the efficiency of industrial activity with respect to its use and/or pollution of natural resources, can contribute to Sustainable Development if it is affordable. Whether it contributes enough to satisfy all interested parties in terms of contribution achieved and affordability is dependent on the values of those interested parties. Recycling is an interesting option in this context because;

> Financial costs and benefits which may make it affordable are divided between more than one agency.
>
> Benefits in terms of reduced pollution and resource use are also divided between different sources of pollution and resource use.

Recycling though, is not the only option which may be promoted by Waste Policy to contribute to Sustainable Development. Other kinds of option include:

Waste Minimisation - Reducing waste necessarily reduces material use per unit of production and can also reduce pollution if polluting emissions are amongst the wastes minimised.

Material Substitution - If scarce materials are replaced with less scarce materials then there is a contribution to reducing resource use. If polluting materials are replaced with less polluting materials then there is a contribution to reducing pollution.

Abatement and Appropriate Waste Management - Polluting substances are prevented from being released to the environment at source ("Abatement") and are thereafter treated or contained to reduce their capability to pollute ("Appropriate Waste Management"). This option contributes to pollution reduction without reducing resource use.

Historically, Waste Policy has been perceived as formulated by governments which stipulated measures to be employed in industry for its implementation. Research into recycling and Waste Policy has traditionally focused on the benefits of recycling and other options at a national level. Recycling required particular attention to enable overall benefits arising from resource use and pollution consequences of changes implemented by many industrial agencies to be accounted for in a national framework and to enable a fair distribution of financial costs and benefits appreciated by agencies involved.

In Chapter Two, it is argued that such research contributes to understanding by showing recycling to be one element of a comprehensive strategy for Sustainable Development which should be considered in the context of the following three issues:

i) Recycling is a means to and end, not an end in itself.

ii) Recycling is not the sole means to a given end.

iii) Differences between recycling and other options may influence the blend of options which can or should be promoted.

In the context of governments stipulating changes to be implemented in industry, the appropriate ends include resource and environmental conservation as well as more political objectives such as increasing employment. Criticism of such additional objectives by authors of the time is presented in Chapter Two.

Recent changes to the style of environmental legislation have moved away from the historic "command and control" approach and towards an approach which includes Industrial Agencies (firms, businesses and corporations) in the process of selecting appropriate waste options. In Chapter Three, a conceptual model is presented which addresses the three issues outlined above but which includes the decision space of Industrial Agencies as relevant to Waste Policy formulation and implementation.

1.5 The Conceptual Model as a Tool for Focussing and Interpreting Research

In Chapter Three, a conceptual model is presented which represents Waste Policy formulation and implementation as an interactive process between Legislative and Industrial Agencies. The model presumes that Legislative Agencies seek to limit resource use and environmental degradation due to industrial activity whilst Industrial Agencies seek to profit from industrial activity. Legislative Agencies regulate industrial activity using regulatory tools and mechanisms. Industrial Agencies implement options to improve environmental performance in order to comply with regulatory requirements. Both kinds of agency develop their own policies.

Legislative Policies provide a rationale for deploying regulatory tools in response to monitored consequences of industrial activity that have negative effects for resource and environmental conservation. The particular rationale employed depends on the objectives of Legislative Agencies regarding resource and environmental conservation and the regulatory tools and mechanisms which are used to influence and monitor environmental performance of Industrial Agencies.

Industrial Policies provide a rationale for implementing options which improve environmental performance in response to costs and benefits anticipated for implementing change. Such costs and benefits are partly due to direct application of regulatory mechanisms to firms, partly due to responses adopted by other related firms (such as waste managers increasing prices due to new practices adopted) and partly due to non regulatory influences (such as consumer demand for environmentally friendly products). The particular rationale employed by any firm depends on the objectives of the firm and how those objectives give rise to appreciation of costs and benefits anticipated for implementing change.

Although the conceptual model represents Waste Policy formulation and implementation, it lacks detail regarding;

The relevant objectives of particular Agencies

What benefits (or disbenefits) of different waste options are recognised by particular agencies

How particular agencies can promote or implement waste options and the limitations of mechanisms available to do so.

A first phase of research is designed to explore Waste Policy from the perspectives of Legislators and Waste Producers and investigate detail which is missing from the conceptual model. The findings of this research are presented in Chapters Four and Five. The findings of the research are interpreted in terms relevant to the conceptual model. In Chapter Six the research findings are either simplified and represented using modeling devices which can be employed with the conceptual model or they summarised as conditions which should be bourne in mind when using the model.

A second phase of research is designed to explore conditions which influence the viability of recycling construction waste by comparison with the null option of continuing to landfill waste without pre-treatment.

The conceptual model and additional details modelled or summarised in Chapter Six are used;

> to direct research into the relevant attributes, conditions and decision criteria of construction firms (the Waste Producers in this case)
>
> to interpret research findings in terms of more general Waste Policy issues, enabling some extrapolation of research output to more general cases of recycling and other waste options

The conceptual model assumes a direct linkage between Waste Producers and Waste Managers which represents transmission of costs and benefits between both agencies as change is implemented. For example, adoption of waste minimisation options by a Waste Producer should be appreciated as lost business by Waste Managers. Conversely, different costs appreciated by Waste Managers for disposing of different wastes should be appreciated by producers of such wastes.

Investigation of waste issues faced by construction firms (presented in Chapter Seven) revealed that they are not sensitive to price distinctions for different kinds of waste disposal. This is due to a failure by Waste Hauliers acting as intermediaries to transmit price information generated by Waste Managers to Waste Producers. The role of Waste Hauliers as intermediaries is investigated in Chapter Eight using a waste transport model developed to estimate effects of prices charged for disposal at a particular landfill site for a particular kind of waste in terms of the amount of such waste attracted to the landfill site.

Having explored conditions relevant to the Waste Producer and the Waste Haulier, the particular conditions of a landfill operation are explored using an economic model presented in Chapter Nine. Legislative conditions are not researched further since research presented in Chapter Three shows that the Legislative rationale applied in the UK does not seek to promote particular cases of recycling. The model presented in Chapter Nine does represent legislative impacts on the landfill industry in terms of increasing costs appreciated by landfill operators.

The economic model is used to show how the financial viability of recycling is dependent on many conditions which the model represents in economic terms. For example, if cost increases due to legislative impacts in the landfill industry are removed from the model (as well as consequent price increases), then the viability of recycling construction waste is reduced (according to the model).

Eight sets of economic conditions (referred to as Scenarios) are explored using the model. Other Scenarios could be generated, but the eight used are representative of the kinds of change to viability which are to be expected according to the mathematic relationships employed in the model.

This modelling exercise demonstrates conditions which influence the viability of one option to recycle construction waste at landfill sites. Other options which

present similar benefits can be considered qualitatively as dependent on similar conditions.

In a broader context, the conceptual model is employed to consider this kind of recycling option in the context of wider ranging issues of Waste Policy formulation and implementation.

Chapter Two presents a literature review which identifies issues which have historically been associated with recycling and Waste Policy in the context of Sustainable Development. This Chapter locates the research in an academic context and identifies issues pertinent for a model of Waste Policy formulation and implementation to address.

CHAPTER TWO

Placing Recycling in The Context of Sustainability

"There is no quality in human nature, which causes more fatal errors in our conduct, than that which leads us to prefer whatever is present to the distant and remote, and makes us desire objects more according to their situation than their intrinsic value"

(D. Hume "A Treatise of Human Nature" Book III Part II Section VII)

2.1 Introduction

This chapter locates the thesis in an academic context of research into Sustainable Development and Waste Policy issues. Historically, research in this field has been driven by a need to inform governmental policy formulation and implementation in the context of managing direct intervention to stipulate waste practices in industry in the interests of Sustainable Development. Such research represents waste issues in national and international contexts, identifies criteria for determining appropriate levels of recycling to be promoted and identifies possible mechanisms for government intervention to promote recycling. Under such a regime, governments were seen as responsible for stipulating changes to practice as well as for environmental and economic consequences of change.

Recent changes to environmental legislation in the UK have transferred some of the responsibility for selecting appropriate waste practices from government to industry. The UK Government remains committed to Sustainable Development and seeks to promote environmental improvement by making Industrial Agencies responsible for environmental and economic consequences of their activities.

In order to inform research into the new style of Environmental Legislation and its consequences for Waste Policy formulation and implementation, literature is reviewed to identify circumstances under which recycling can contribute to Sustainable Development.

2.2 Definitions

The Oxford English Dictionary (OED) offers four definitions of relevance to recycling in the context of this study:

"Cycle....

A round, course, or period through which anything passes in order to its completion; a single complete period or series of successive events, etc."

(OED 1978)

"Recycle....

a. To reuse (a material) in an industrial process; to return to a previous stage of a cyclic process.

b. To reuse (a waste material), to convert (waste) into a usable form; also to reclaim (a material) from waste."

(OED supplement 1982)

"Waste....

of materials, incidental products, etc.: Eliminated or thrown aside as worthless after completion of a process: refuse."

(OED 1978)

This research focuses on "recycling" according to definition "b" above. Definition "a" presumes the existence of a cyclic industrial process (as a consequence of and enabling recycling) this form of recycling is considered as a subset of "waste minimisation". When the distinction between different types recycling is required, those which are part of a cyclic process are called "internal recycling". When "recycling" is being emphasised as referring to definition "b" (as it does by default in this report) the phrase "external recycling" is used.

The words "internal" and "external" relate to system boundaries of industrial processes. Determination of system boundaries depends on the roles of particular agencies involved. This vagueness of definition is appropriate for considering waste issues from multiple perspectives since different agencies can and do perceive recycling and other waste options according to subjectively determined boundary conditions.

For example, consider a building site where a building is to be replaced with a car park. The demolition team may be instructed to leave behind any rubble usable in the car park foundations as hardcore. From the team's point of view this material is reclaimed from other wastes for recycling. From the point of view of the team arriving to lay car park foundations, the rubble left behind is recycled material (this may involve them in checking material quality). For both teams, the recycling involved is external since the first team are not involved with re-use and the second team are not involved in reclamation. However, from the site manager's point of

view, the recycling is internal to the process managed and could be considered as a waste minimisation exercise. The distinction between internal and external recycling is dependent on the context within which subjects perceive waste issues.

2.3 Background: Economic Views of the Environment.

Early in the 1970's, application of variance theories led to two kinds of development in environmental economics.

i) Attempts to develop large "accounting" models incorporating variables to represent negative consequences of consumption of environmental and material resources. (Meadows et Al. 1972)

ii) Thought experiments in economics described the kind of economic variable which policies of the day effectively treated the environment as (a limited resource donated at no charge to industry).(Freeman et Al. 1973)

Such developments were limited by:

The fact that social and environmental systems did not in reality give rise to meaningful, measurable phenomena, which behaved according to simple economic rules.

The need to develop operational policies for change rather than descriptions of ways in which established policies were limited.

By the end of the 1980's, some economists had recognised that, in the absence of complete reduction to variance models, acceptance of value judgements in place of rigorous analysis enabled some form of "Sustainable Development" to be pursued. "Sustainable Development" remains a politically defined and value laden objective rather than a scientifically determined "optimum solution" to environmental and resource problems.

During this period (1970-1990), "Recycling" served as a prime example of failures by the milieu of Legislative Policies to address environmental and resource issues.

In economic terms, one symptom identified was failure to incorporate full social and environmental costs into all stages of industrial activity.

Environmental economics has now become a body of knowledge in its own right, although this was not always the case. Until recently, the environment was considered by economists to be too complex a system involving unfathomable causal linkages to lend itself to useful economic interpretation.

Meanwhile environmentalists could draw on a wealth of examples to demonstrate the terrible consequences of certain money-making activities on the basis of which they could provide powerful counter arguments (based largely on experience and inference) to projects which owed their potential and justification to economic deductions.

Ultimately, decisions are made by weighing up pro's and con's, but when these pro's and con's are argued in vastly different conceptual frameworks we may sympathise with the decision maker. Ultimately decisions are taken according to whatever conceptual frameworks decision takers of the time apply to the problems at hand. Simple conceptual frameworks are commonly applied since they are powerful tool for addressing simple problems. However environmentally related problems generally involve complicated and complex phenomena. This issue was recognised by the Club of Rome who put it that:

> "Decision-makers at every level unconsciously use mental models to choose among policies that will shape our future world. These mental models are, of necessity, very simple when compared with the reality from which they are abstracted."
>
> (Meadows et al. 1972. p.20-21)

In "The Limits To Growth" the Club of Rome go on to simplify many issues including environmental degradation and depletion of non-renewable resources, rendering them more accessible to economic interpretation. Meadows et al. confess that,

> "The model we have constructed is, like every other model, imperfect, oversimplified, and unfinished."
>
> (Ibid. p.21)

Despite argument that this could be the nature of any attempt to reduce the complexity surrounding environmental issues, the work of the club of Rome has succeeded in drawing attention to the need for further refinement of such models.

That the environment deserves consideration in economic terms is well justified by Freeman et al., who define the environment as:-

> "a kind of natural asset or nonreproducible capital good which is the source of economically valuable direct and indirect services to man. These services include residuals absorption or waste receptor services as well as life sustaining, amenity, and materials supply services. These services are all economic goods in the sense that people are willing to pay to receive more of them or to avoid a reduction in the quantity or quality of the services that they provide."
>
> (Freeman et al. 1973 p.22)

Pearce also recognises the potential value of such services and that in the absence of an adequate "environmental balance sheet" to account for them (e.g. if they are available at zero cost) demand will be heightened not necessarily according to supply capacity. Pearce also points out that people are willing to pay for such services, but also that it is hard to identify the beneficiaries of them and evaluate the benefits in monetary terms.

To tackle this problem, Pearce introduces the idea of "Sustainable Development" which was postulated by the Club of Rome in conjunction with zero growth as an acceptable remedy to what they saw (pessimistically perhaps) as an inevitable collapse of the world system if subjected to unbridled growth.

Pearce's view of Sustainable Development on the other hand is less restrictive as it does allow for some continued growth. In this context "growth" refers to increased amounts of industrial output whilst "development" refers to increased utility of industrial output.

Pearce views development as consisting of "components" which he is vague in defining but which include; economic well-being, quality of life, societal equity, environmental quality, sensible allocation and upkeep of resources and intergenerational equity with respect to some function of the "components of development." These components are linked to the achievement of social goals, which Pearce leaves to society to define but which he recognises as moving as rapidly as they are achieved. Hence Sustainable Development itself is a moving target (Pearce 1989. p.29).

With respect to the problem of accounting for the environment, Pearce succeeds in reducing the problem to a meta-level guiding function that as long as economic growth is not at the expense of some other component of development then it is embraced by sustainable development as defined by the morals of the society of the day (or political representation thereof).

Resource conservation is a significant element of long term well-being. This subject is expounded well in this context in the paper "Scarcity of Basic Materials and Fuels: Assessment and Implications" (Govett & Govett 1977 p.33-62). Govett & Govett deal with the geological and technical constraints on the supply of raw materials and briefly with the "political realities of assuring the world adequate mineral supplies." (Ibid. p.34)

They point out that, despite the logical capability for extracting minerals from any rock, geographic concentrations of elements in the earth's crust which make it economic to mine the ore are geologically rare. A known deposit of ore will therefore only contain a fraction which is of sufficient quality to warrant extraction. This fraction is in turn determined by current states of technology and raw materials markets.

> "On a regional, national, or international basis reserves are defined as `known deposits from which minerals can be extracted profitably under present economic conditions and with existing technology.'"
>
> (Ibid. p.48)

This idea is represented in Fig 2.1.

Scarcity then is a relative factor:-

> "relative to future demand, and, most importantly, relative to such factors as exploration success, mining techniques, processing technology, and world mineral prices." (Ibid. p.34)

Govett and Govett go on to point out that, the majority of known resources, as well as of unexplored areas (regarding minerals), are in less developed countries. Given the current extent to which such countries depend in many cases on exploitation of labour and the environment, and that such issues are currently politically sensitive, and that such countries are in great need of money, they go on to speculate that an increase in the supply price of minerals

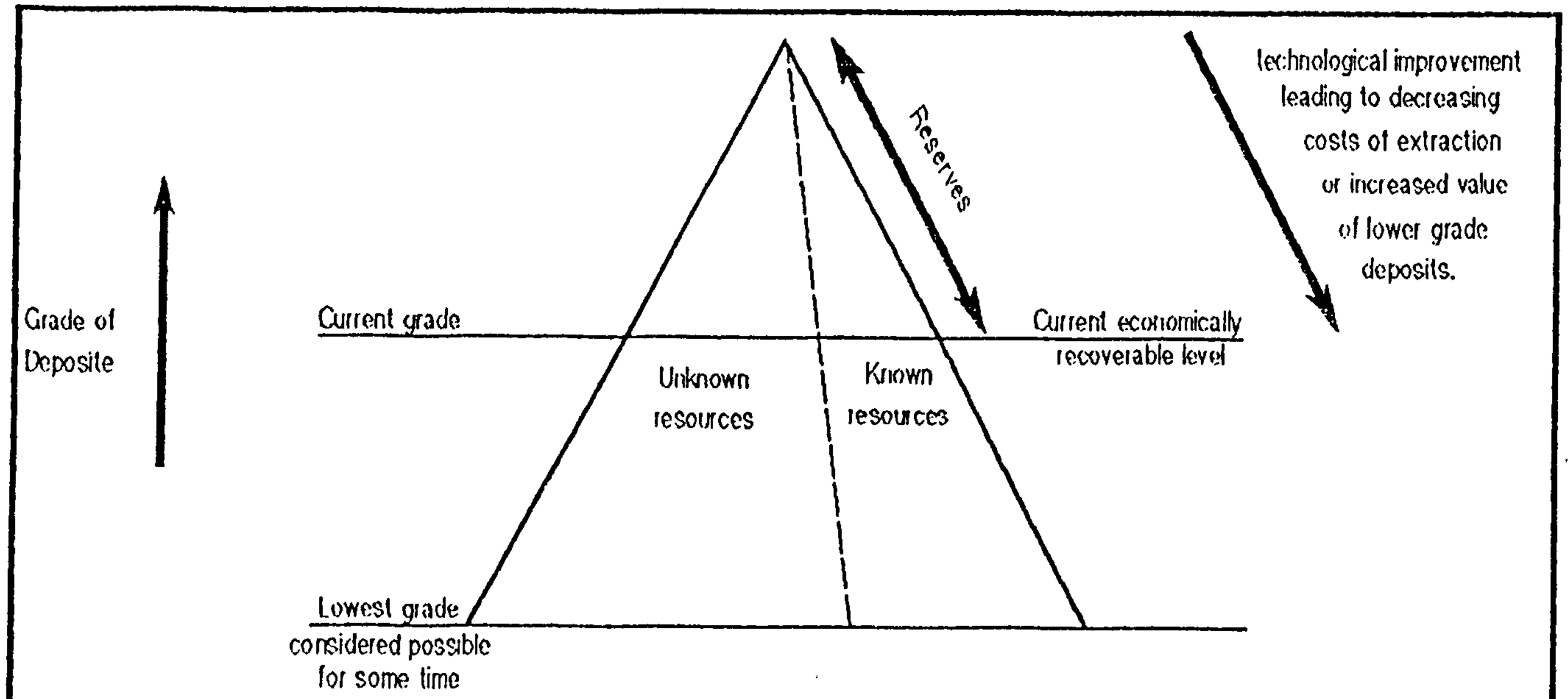


Fig 2.1: Adapted from Govett and Govett 1977 p.48

Reserves of known resources can be increased by:
sucessful exploration
decreased cost of extraction through inproved extraction techniques
increased demand for lower grade minerals through improved processing techniques or other downstream causes.

would be in the interest of such countries. That such a state of affairs might be brought about by such countries taking co-operative action for example supports Wolbeck's prediction of a trend of rising raw materials costs (Section 2.4).

In summary then, economic tools such as measurements of willingness to pay and intergenerational allocation of resources may prove useful when dealing with the environmental aspects of recycling. More importantly though, the natures of some of the factors to be weighed and balanced when considering the environment do not readily lend themselves to reduction in economic terms. Sustainable Development is a contentious topic in its own right which will not be discussed further here, except to say that Pearce's use of it suggests:-

> a need to develop a conceptual framework for decision makers of which economics may be a part alongside other "components" rather than attempting a complete reduction of the issues into an economic framework.
>
> that "Sustainable Development" is a politically defined concept arising from the policies of governments of the day.

2.4 Recycling: Social and economic aspects.

Despite failure to rigidly define "Sustainable Development" many author's mention that recycling is one of the things which can contribute to its achievement. To begin an exploration of why this is so, it is helpful to consider why recycling may contribute.

A first step to identifying the potential role of recycling in Sustainable Waste Policy is taken by Bower who points out that:-

> "No production or use activity converts 100 percent of the material and energy inputs into desired products and services. There are five `fates' for these nonproduct outputs (NPOs): (1) material/energy recovery; (2) by-product production; (3) discharge into one or more of the three environmental media - land, air, water - with or without modification; (4) processing to obtain materials for use as subsequent inputs to production or energy conversion; and (5) the re-use in the same form."
>
> (Bower 1977 p.1-2)

Discharge (3) of Bower's "NPOs" can be at the expense of environmental quality. Modification to reduce environmental damage or an alternate fate for the NPO's could be promoted if society places value on the environment. As Bower points out though:-

> "In many cases direct discharge - or discharge with minimal modification - is still the least expensive option, even in social terms."
>
> (Bower 1977 p.3)

There is a distinction to be made between the benefits to society by virtue of the aversion of environmental degradation and the benefits to polluters by aversion of costs of alternative treatment of NPOs. In order to consider the discrepancy between

a social desire to reduce pollution and the motivations of polluters, it is helpful to look to the policies which supposedly govern the latter in the interests of the former. Such a task is less simple than it might at first appear.

> "Recycling cannot be analysed adequately, nor rational policies with respect to it developed without a clear understanding of the multiplicity of factors that affect the extent of recycling as they relate to different materials/energy and to different economic activities. It is particularly important to recognize that: (1) policies not specifically directed toward recycling can have important effects on recycling, such as tax and pollution control policies; and that (2) changes in input prices, such as energy, crude petroleum, and services can have major impacts on recycling." (Bower 1977 p.18-19)

One reason then why recycling might be desirable is that various forms of it are preferable alternatives to discharge into the environment of pollutants. The policy issue though of how to motivate polluters to change their habits would seem to be complex.

This same problem is recognised by Wolbeck.

> "A particular threat to the environment is caused by hazardous industrial wastes, with their high concentrations of pollutants. Methods needed for a proper treatment and monitoring are either insufficiently available or inadequately applied."
>
> (Wolbeck 1977 p.24)

Wolbeck also embraces raw materials and energy aspects in his analysis of recycling, which may help in "understanding of the multiplicity of factors that affect the extent of recycling".

More recently, Authors have recognised a shift from command and control regulatory strategies towards the use of Economic Instruments (EI's) and a consequent need for coherent consideration of system-wide effects to achieve comprehensive environmental improvement in industry.

> "EI's do not, however, in themselves mitigate the problem of information failure and they will also require careful deployment with due regard to system-wide effects and the need for integrated management."
>
> (Turner et Al 1994 p.258)

In particular, adoption of systems thinking and use of simple economic techniques seems to be needed as responsibility is devolved to industrial agencies.

> "few countries have agencies which have taken an overall systems perspective when dealing with waste planning and management, and the lack of cost benefit thinking has also been commonplace"
>
> (Ibid p.253)

Examples of how EI's address different kinds of waste issue are now commonplace in the literature (Mennell 1990, Pearce and Turner 1992 & 1993, Turner and Powell 1991).

Rather than separating these issues out and treating them individually, Wolbeck proposes a "comprehensive policy" approach.

> "With regard to the twin objectives `resource conservation' and `protection of the environment,' the policy for secondary materials management is directed at the following aims:(1) reduction of no longer utilizable materials (wastes) at the production and consumer levels by reducing wastes generated in the production process, applying environmentally sound production techniques (reduction of air and water pollution), extending life of products, and increasing the re-use of products; (2) substitution of scarce for less scarce raw materials in the production process (while retaining the purpose for which the product is to be used); (3) increased utilization of wastes by recycling during the production process (recovery of materials), recovery of the energy content of wastes and feedback into biological cycles; and (4) environmentally sound disposal of wastes. These objectives are not to be regarded as separate and isolated tasks. Rather they should be tackled in a joint approach, taking into account the materials concerned."
>
> (Ibid. 1977 p.26)

With respect to implementing such a policy, Wolbeck outlines two major problems. The first is that:-

> "The collection, evaluation and provision of relevant information on wastes are essential prerequisites for any systematic planning of recycling."
>
> (Ibid. 1977 p.27)

Historically such information was often unavailable where it was needed.

> "adequate knowledge on the composition of wastes, for example, does not exist even at the factory level where these wastes are generated."
>
> (Ibid. 1977 p.28).

Also, where resources are scattered, then the problems of transport and sufficient utilization of capacity can only be overcome by coordinating the multiplex interests of individual plants.

> "Increased recycling more and more calls for giving up a philosophy based on the concerns of individual plants."
>
> (Ibid. 1977 p.29)

This problem has been addressed by recent regulations (Integrated Pollution Control licences require compilation of information about wastes as does acquisition of the British Standard for environmental management - BS:7750).

The second problem which Wolbeck raises is that of raising the demand for recycled or part recycled products (despite the importance of increasing collection and reprocessing rates).

> "Taking into account that product design and product requirements are connected, expanded utilization of secondary materials will decisively

depend on the following three conditions: (1) development of new production techniques; (2) development of new products and marketing potentials; and (3) change of requirements on products, frequently in the sense of reducing certain quality requirements."

(Ibid. 1977 p.30)

Wolbeck also points out that "recycling design" can play a part in making recycling "economically and ecologically defensible", as opposed to being treated as an end in itself.

> "Recycling design is concentrating on the following tasks: (1) designing of products with a view to facilitating their recycling after use, and (2) designing and developing new products with the aim of increasing the portion of secondary materials (prior to use) in the products."
>
> (Ibid. 1977 p.30)

Another enabling factor for recycling to flourish in conjunction with Wolbeck's other objectives is that of a shift in consumer attitudes from previous conceptions of quality which might not be met by recycled products although such products may be sufficient for the intended purpose. (Ibid 1977 p.32)

Wolbeck finishes by arguing that environmental and resource conservation are related to economic growth, although the costs associated with adopting a "comprehensive policy" would outweigh such benefits in the short term. To do nothing could lead to calamity due to resource cost increases, if not a great cost in the future, whilst delaying such measures can only increase the short term cost of change as the system becomes more reliant on established practices.

> "What he (the politician) fails to do today will cost him dearly tomorrow."
>
> (Ibid. 1977 p.32)

With regard to the issue of need for recycling, Wolbeck can be taken as recommending that recycling should not be persued as an end in itself but as part of a comprehensive policy to conserve resources and protect the environment which in turn are necessary to long term well-being.

Govett & Govett's conception of raw materials (Section 2.3) raises another issue which is that relaxing quality requirements and quality demands on products might encourage the exploitation of lower grade resources as much as encouraging the use of secondary materials. This could be interpreted as conforming to an aim of substituting scarce for less scarce materials and so it remains a means to developing a comprehensive policy. It also suggests though that this resource connotation to relaxing product quality should be considered along with its effects on recycling.

Wolbeck's argument has been presented in some detail because he considers many of the issues dealt with by other authors in a coherent framework. How other authors develop these issues beyond Wolbeck's treatment of them is considered below.

Wolbeck stressed the need to understand the "multiplicity of factors affecting materials recycling", but does not attempt to further specify these factors and

their relationship to market structure and the role of policy makers regarding such factors.

Anderson questions whether the free market can provide "the correct amount of recycling" and examines the "appropriate role for government" in correcting any existent deficiencies. (Anderson 1977 p.158). He considers these issues from the perspective of "maximising the present value of social welfare." (Ibid. p159)

Anderson writes with respect to U.S. policy, enumerating cases of market failure "in which goods are not priced at their full social cost of production" (Ibid. p.165) and goes on to prescribe remedial policy changes usually based on the principle that "societal welfare is enhanced by equal treatment of investment in all activities" (Ibid. p.166).

The method of Anderson's analysis is more relevant here than his conclusions. His method was to divide the flow of materials into sections and draw out the reasons for market failure in each sector. These points are summarised below, using Anderson's section titles.

Anderson represents material flow as in Fig 2.2, showing the flow of materials between the eight sectors distinguished below along with the associated market failures highlighted by Anderson.

1. "Primary Extraction:"

   Converting virgin natural resources into forms suitable for primary processing By-products include pollution and disruption of scenic natural environments. Instances of market failure include: externalisation of the social costs of by-products; tax benefits to a greater degree than those experienced by industry at large and; monopolistic forces allowing manipulation of markets.

2. "Primary Processing:"

   Converting resources into forms suitable for manufacturing. By products include pollution, particularly effluents and scrap, some of which is recycled internally. Market failure is predominantly in the form of the externalisation of social costs of effluent pollution.

3. "Primary Manufacturing:"

   Converting materials from primary and secondary processing into items suitable for primary consumption. By products include scrap (much of which is returned to primary processors or secondary collectors), and various forms of pollution. Again market failure in this area is related to pollution.

4. "Secondary Collection:"

   Converting by-products from primary processors and consumers into forms suitable for primary or secondary processing. By-products may include pollution due to excessive transportation which may cause a degree of market failure in this sector

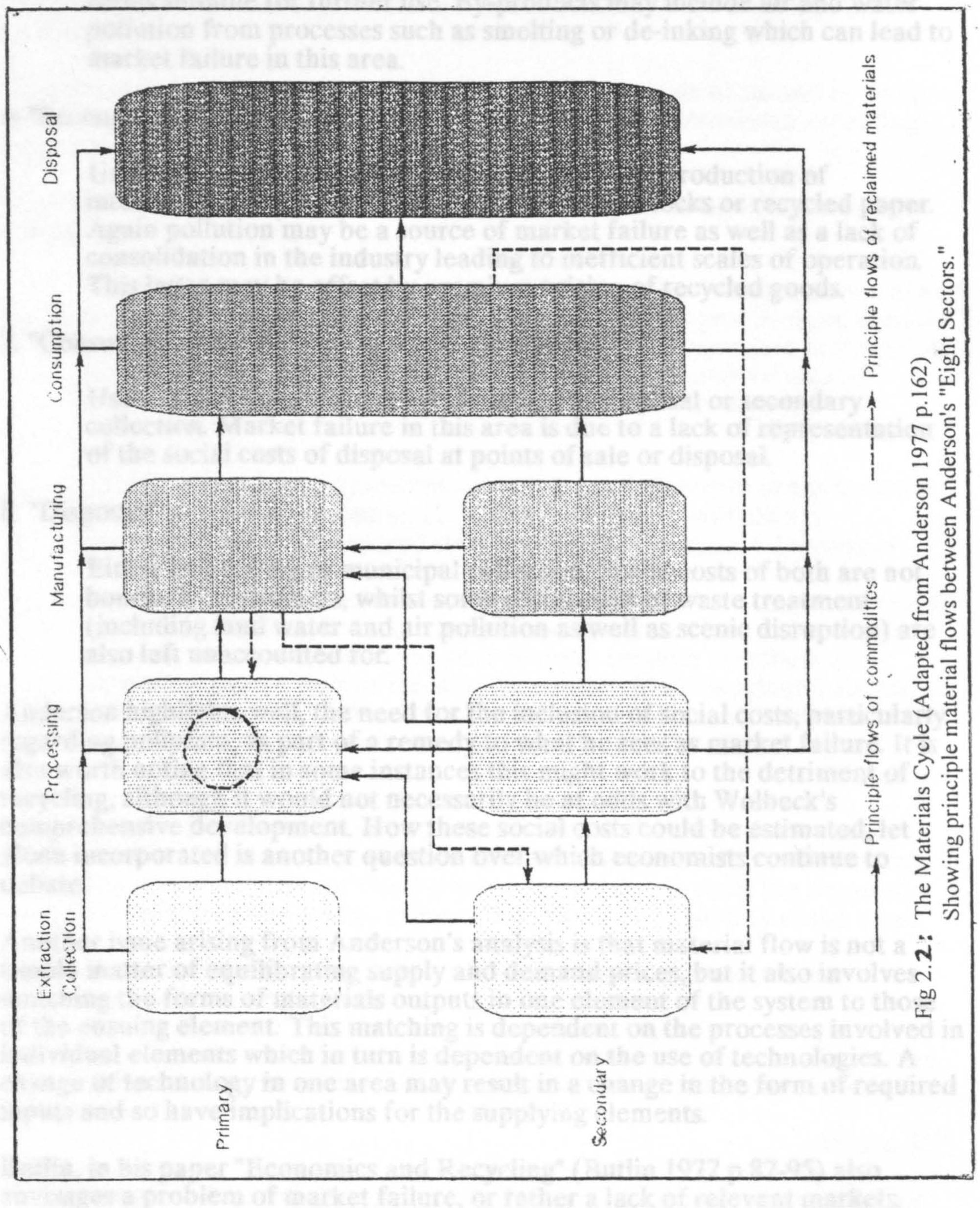


Fig 2.2: The Materials Cycle (Adapted from Anderson 1977 p.162)
Showing principle material flows between Anderson's "Eight Sectors."

along with subsidisation in the form of grants or use of voluntary labour.

5. "Secondary Processing:"

> Often necessary to convert materials from secondary collection into forms suitable for further use. By-products may include air and water pollution from processes such as smelting or de-inking which can lead to market failure in this area.

6. "Secondary Manufacturing:"

> Usually uses purely secondary materials for the production of intermediate or end use goods such as engine blocks or recycled paper. Again pollution may be a source of market failure as well as a lack of consolidation in the industry leading to inefficient scales of operation. This latter may be offset by premium pricing of recycled goods.

7. "Consumption:"

> Use of finally produced goods followed by disposal or secondary collection. Market failure in this area is due to a lack of representation of the social costs of disposal at points of sale or disposal.

8. "Disposal:"

> Either by littering or municipal collection. Social costs of both are not bourne by consumers, whilst some social costs of waste treatment (including land water and air pollution as well as scenic disruption) are also left unaccounted for.

Anderson highlights well, the need for the inclusion of social costs, particularly regarding pollution, as part of a remedy to what he sees as market failure. It is also worth noting that in some instances this might work to the detriment of recycling, although it would not necessarily be at odds with Wolbeck's comprehensive development. How these social costs could be estimated, let alone incorporated is another question over which economists continue to debate.

Another issue arising from Anderson's analysis is that material flow is not a simple matter of equilibrating supply and demand prices, but it also involves matching the forms of materials outputs in one element of the system to those of the ensuing element. This matching is dependent on the processes involved in individual elements which in turn is dependent on the use of technologies. A change of technology in one area may result in a change in the form of required inputs and so have implications for the supplying elements.

Butlin, in his paper "Economics and Recycling" (Butlin 1977 p.87-95) also envisages a problem of market failure, or rather a lack of relevant markets.

> "The problem (deteriorating natural environment and dwindling stocks of natural resources) lies partly in the non-existence of markets in which

> a supply of and demand for disposal facilities for industrial and domestic waste could be registered."
>
> (Butlin 1977 p.88)

The Science Research Council (SRC) in their publication, "Making the Most of Materials", describe some general implications of materials recycling (SRC 1979 Chapter 9).

They assume that recycling is beneficial due to a finiteness of resources and a positive influence on the balance of trade without going into detail regarding these issues.

They highlight some central issues concerning recycling using thermodynamic principles.

> "(Second law of Thermodynamics) no heat engine, energy transformation or chemical reaction can work at 100% yield under practical conditions. Thus, 100% efficiency in any recovery process is impossible in theory as well as in practice, where accidental losses and dissipative uses of materials remove them permanently from the production cycle."
>
> (SRC, 1979 p.162)

> "(Clausius's statement) the entropy (degree of disorder) of the universe is increasing to a maximum, i.e. an ordered system will always degenerate into a disordered state, given time. Workable deposits of metallic ore arise from their sources having been concentrated, by geological phenomena, into non-random pockets where they are present to many times their average crustal concentration. From these high concentrations, minerals tend once more to random distribution by natural processes such as leaching by rainfall. Man contributes to this global redistribution when metals are extracted from areas of high concentration and dissipated over the surface of the globe."
>
> (Ibid. p.162)

Re-ordering of disordered states requires the input of energy often at many stages of a multi-stage process which is not thermodynamically reversible (e.g. production processes). Hence dissipation of materials increases the required energy for their recovery and so reduces the economic feasibility of the same.

The SRC also realise the significance of externalised social costs when motivation for action is, to some extent, profit.

> "The degree to which reclamation is practised will vary according to the levels of monetary costs (which are quantifiable) and social costs (which are not)."
>
> (Ibid. p.163)

They go on to analyse this situation according to internal costs appreciated by firms and external "social costs" which are harder to quantify (summarised Fig 2.3). However, they fail to demonstrate how the non-quantifiable social costs could be measured on the same axis as quantified costs. Fig 2.3 demonstrates the unsurprising result that incorporating full social costs into costs of production may favour an increased recycling rate.

The SRC also argue that other commercial considerations can be significant. Given that the amount of secondary materials available at a time is a function of the quantity of raw material going into service at the beginning of the useful life of a commodity (perhaps many years earlier) then (accepting also an increasing demand for materials over time) secondary materials supplies will always fall short of demand. In this case there will be a need for the supply of raw materials as long as demand for materials is not decreasing at a rate to allow for inefficient reclamation of materials. That this is the case suggests that in times of recession, manufacturers will favour a reduction in the use of secondary materials rather than raw materials for fear of jeopardizing supply of the latter. This process acts as a source of positive feedback in favour of raw materials as it makes recycling more vulnerable during recession (Ibid. p.166-167).

This issue is dealt with in more depth by Beijdorff et. al. who demonstrate that paper recycling markets are subject to fluctuations between "underpressure" (too little supply and high prices) and "overpressure" (prices too low) (Beijdorf et. al. 1982 Chapter 9),. When considering paper (a fairly short lived product) it was noticed that waste paper traders respond slowly to such fluctuations (more slowly to overpressure than underpressure) especially after periods of extreme underpressure. When the price for paper pulp is high (due to a timber shortage say), then the waste paper trade is stimulated whilst the amount of paper produced may decrease. As the price rises, timber markets may recover to undercut waste paper which is now dependent on the recent low paper production rate. There is a time lag associated with fluctuations as entrepreneurs need to become convinced of a market for waste paper before investing and a lack of such a market before quitting.

An issue addressed by Oxfam (Oxfam 1978) and Turner (Turner 1981 Chapter 5) is that currently profitable forms of recycling, which tend to be characterised by involving voluntary labour or by being highly internal forms of recycling, are already pursued to a great extent and that to increase recycling would require stimulating it in its less profitable instances. Oxfam argue that recycling occurs less, the more removed from organisationally internal processes recycling activity becomes as this leads away from "economies of self interest" (except where voluntary organisations intervene).

Oxfam and Turner argue that the disbenefits of stimulating less profitable forms of recycling can be offset against social benefits such as increased employment (as less internal recycling becomes more labour intensive).

This argument is opposed by Lindgren (Lindgren 1986 p.175-192), who discounts creation of jobs as a reason for government sponsorship of recycling as opposed to say creating a shoe factory. Lindgren argues that recycling should be treated as a means rather than an end. He illustrates his argument well with the example of paper recycling in Sweden. Given that Sweden has well environmentally managed, renewable forest sources of wood for pulping, then competition from recycled paper could lead to a decline in the need for such forests which might then become deforested and replaced by factories, much to the discomfort of environmentalists.

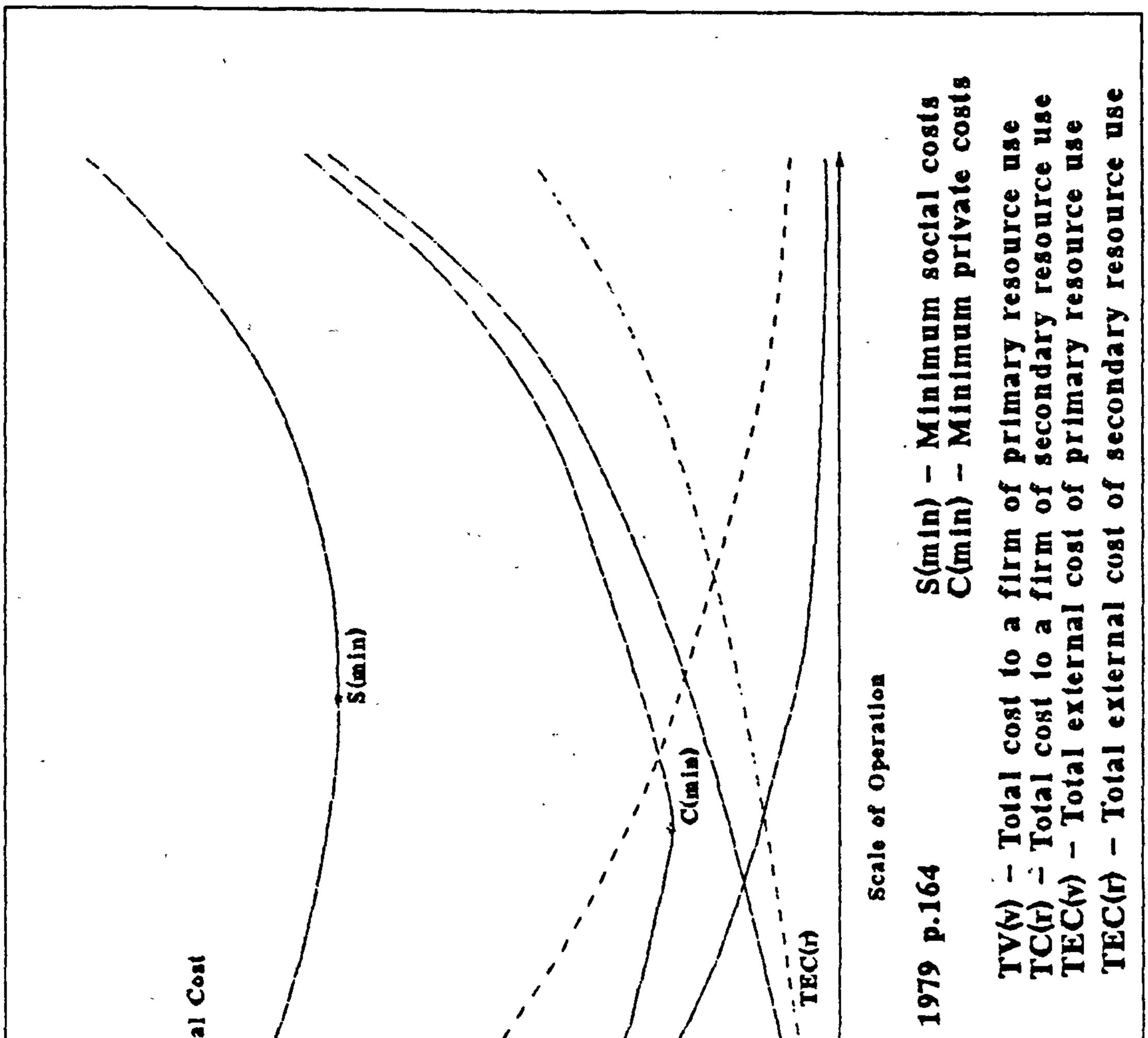


Fig 2.3: Adapted from SRC 1979 p.164

Lindgren argues that government consideration of recycling sponsorship should be dependent on the merits of individual cases rather than an overriding rule to prioritize recycling as something which is necessarily good. Although Lindgren seems critical of recycling, his argument is directed at recycling as an end in its own right rather than at recycling as part of a comprehensive strategy. His argument against considering labour factors as a benefit to recycling is only to the extent that if labour is to be considered then it must be done so comprehensively (i.e. applying as much to a unit of labour in a potential other use of public funds as much as to recycling). He does differ radically from Wolbeck in that he is more cynical of resource shortage predictions. Regarding the Club of Rome's computer aided prediction of a catastrophic oil shortage inside of thirty years, he says:

> "However if natural resources are permitted to increase by between one and two percent a year due to new discoveries and new technological advances, and if the possibility for controlling pollution increases at the same rate, then the Club's world model will not lead to catastrophe."
>
> (Turner 1981 p.188)

Such a conception of resources is expounded by Govett and Govett (See Section 2.3) who describe qualitative conditions under which raw materials prices might sharply increase. Anderson points out also that there can be market failures to account for full costs of resource exploitation due to policies aimed at keeping raw materials prices low for manufacturers, which are not similarly applied to secondary materials exploitation. Turner's criticism then would hold if the full costs of his one to two percent increase in resources were reflected in the raw materials price. This point would also depend on a lack of politically instigated resource catastrophe as described by Govett and Govett.

The issue of designing products to be recyclable is expounded well by Jordan (Jordan 1984) who considers the role of the design as a learning process (concerning the end use and recycling of products) as much as a designing one. If a designer is to incorporate recyclability into his designs ("recycling conform design") then he must be aware of information regarding production processes, and maintenance procedures on systems of which the product may be a part, or on parts of the product. Only when such information is fed back to the designer can he weigh up factors such as lifetime of a part, it's recycled material content, and its recyclability (dependent on its ease of removal and refitting and contamination with "pernicious contraries"). This flow of information is represented in Fig 2.4.

Jordan goes on to point out fringe benefits of recycling conform designs, such as that they tend to be "maintenance conform" as well. He also draws some guide-lines for designers aiming for recycling conformity. These guide-lines include, easy assembly and disassembly, standardisation of parts, maximising lifetimes, minimising non-recyclable waste, and identification of materials by labelling. Jordan not only gives practical advice for designers but also highlights the importance of communication for establishing effective recycling strategies.

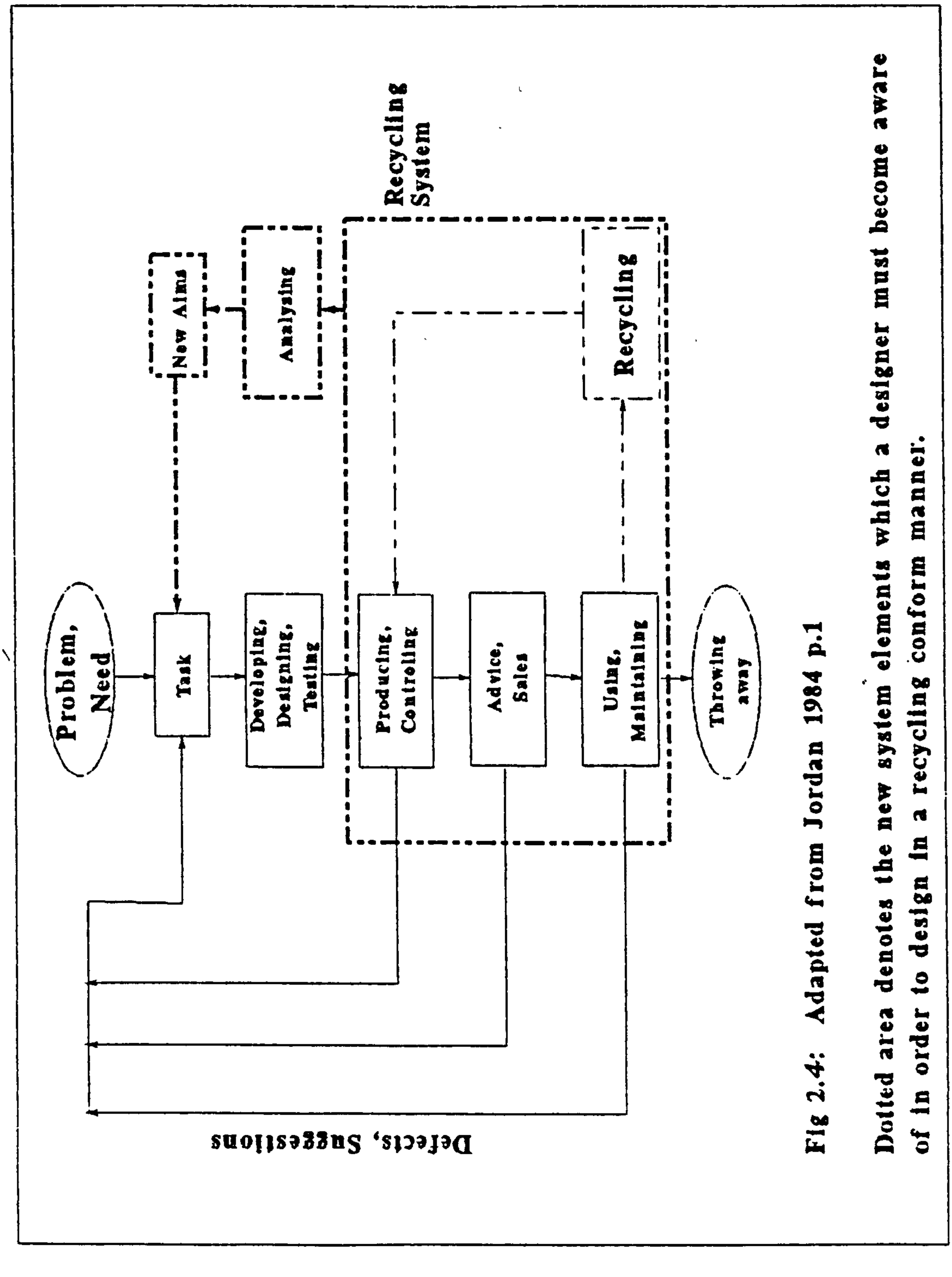


Fig 2.4: Adapted from Jordan 1984 p.1

Dotted area denotes the new system elements which a designer must become aware of in order to design in a recycling conform manner.

2.5 Conclusions for Research Context

In Section 2.2, it is argued that "recycling" is a subjectively defined word the meaning of which depends on the perceptions of agencies from whose perspective waste is considered. The literature presented in Sections 2.3 and 2.4 considers national and international boundary conditions appropriate to Waste Policy implemented through intervention by national governments. In Section 2.5 it is argued that new forms of Environmental Legislation require the decision spaces of Industrial Agencies as well as Legislative Agencies to be considered to inform a more modern conception of waste issues.

Despite changes to legislative style, the findings of previous research are still important for identifying the conditions under which recycling contributes to Sustainable Development. In order to consider whether modern governmental policy succeeds in promoting Sustainable Development in the context of Waste Policy formulation and implementation, it is necessary to identify the contribution of improvements in waste practices to Sustainable Development and the conditions under which recycling, and other waste options, make such a contribution.

In Section 2.3 it is argued that "Sustainable Development" and the associated concept of "resource scarcity" are defined as much in political terms as scientific terms. In the absence of absolute definition of these phrases, understanding can be facilitated by identifying the political objectives to which Waste Policy formulation and implementation can contribute.

In Section 2.4 it is argued that the views of authors who have considered waste policy issues are congruent with the following recommendations regarding recycling and political objectives which Waste Policy should address in the interests of Sustainable Development:

i) Recycling is a means to an end not an end in itself

ii) Recycling is not the sole means to the same end

iii) Differences between recycling and other options may influence the blend of options which can or should be promoted

The end to which waste options may contribute is identified by Wolbeck as a twin objective of resource and environmental conservation. Options which contribute to these objectives include;

Recycling

Waste Minimisation

Material Substitution

Abatement and Appropriate Waste Management

(Wolbeck 1977 p.26)

These ideas are used in Chapter Three to develop a first approximation to a conceptual model of Waste Policy formulation and implementation which includes the decision space of Industrial Agencies as is appropriate for the modern legislative regime. This conceptual model is used to design research into modern Waste Policy formulation and implementation and interpret research findings in a way which enables the conceptual model to be refined in the light of additional detail discovered.

This chapter commences by placing the research in the context of "Sustainable Development". More specifically, the process of conceptual model building locates the research as an extension of research in the field of economics into Waste Policy. However, economics is limited in its ability to consider the more political aspects of issue related to Sustainable Development (Pearce 1989). Although inclusion of the decision space of Industrial Agencies does beg economic questions it also raises issues regarding non-economic influences on firms to improve environmental performance such as regulation and access to appropriate skills and resources to implement waste options.

Identifying and representing forces and barriers to change introduces social science techniques and systems thinking into the research. Some parts of the research involve consideration of legal documentation and a case study is presented which introduces logistic and micro-economic modeling. These multidisciplinary activities are integrated by locating each in terms of the conceptual model which drives and is informed by the research.

CHAPTER THREE

Research Design

"While a warm imagination is allowed to enter into philosophy, and hypotheses embrac'd merely for being specious and agreeable, we can never have any steady principles, nor any sentiments, which will suit with common experience. But were these hypotheses once remov'd, we might hope to establish a system or set of opinions, which if not true (for that, perhaps, is too much to be hop'd for) might at least be satisfactory to the human mind, and might stand the test of the most critical examination."

(D. Hume 1740: "A Treatise of Human Nature" Book I, Part IV, Section VII)

3.1 Introduction

Blue Circle Waste Management Ltd (BCWM) have a keen interest in legislative issues which effect changes in practice adopted by waste producing customers and affect their wastes arising and thus affect BCWM's business. The original remit of the research project was to investigate recycling in the broadest possible sense in order to improve understanding of upstream conditions which affect the viability of recycling as an option that could compete with landfill.

BCWM also have a direct interest in recycling as a possible alternative to established waste management practices. BCWM's interest arises from a preference to operate viable recycling operations than to compete with them. During the later stages of the research project, BCWM's Managing Director expressed a desire for the research project to be directed at considering how to assess the viability of recycling opportunities for BCWM.

In this chapter, a conceptual model of Waste Policy formulation and implementation is developed:

> **as an extension of previous research into recycling and Waste Policy into the domain of modern industrial regulation which empowers Industrial Agencies as participants in the process of formulating and implementing Waste Policy,**
>
> **(Section 3.2)**
>
> **as a framework for investigating current strategic issues faced by Waste Producers and Legislative Agencies that are relevant to the modern process of Waste Policy formulation and implementation and which give rise to changes in wastes arising and so impact on Waste Managers (such as BCWM),**
>
> **(Sections 3.2 and 3.3)**

> as a tool to inform a case study focusing on assessment of one recycling option and to enable extrapolation of research findings to more general cases of recycling and other waste management options.
>
> (Section 3.4)

This chapter also presents rationales for the particular research activities conducted. The research is not designed to exhaustively explore every issue and problem identified but is targeted at identifying issues and problems experienced by different agencies involved in the process of Waste Policy formulation and implementation. Rather than resolving issues and solving problems, the research seeks to show the kinds of circumstances which influence the particular resolutions and solutions currently achieved by different agencies.

By comparing circumstances applicable to agencies involved in Waste Policy formulation and implementation it is possible to show congruence or incongruence between the objectives of agencies, the action taken by agencies and the consequences of such actions. Although individual research activities concentrate on individual agencies, the findings of research are incorporated into the conceptual model to enable analysis of situations involving multiple agencies.

This kind of situation is a product of modern Environmental Legislation which empowers rather than instructs industry. The methods presented are employed to explore the consequences of empowering Industrial Agencies as active participants in Waste Policy formulation and implementation in terms of the kinds of policy issues which have historically been resolved primarily by Legislative Agencies that instructed Industrial Agencies to adopt prescribed practices.

3.2 Translating Policy Issues into Research Questions

The three issues summarised in Section 2.5 have bearing on policy formulation for Sustainable Development and particularly for Integrated Waste Policy in that context. Given some legislative demand for change which may involve promotion of recycling, these three issues may be stated as three factors which should be taken into account during waste policy formulation processes.

A. The extent to which recycling contributes to achievement of the goals and objectives of Sustainable Development.

B. The extent to which other options contribute to achieving the goals and objectives of Sustainable Development.

C. The extent to which differences between recycling and other options matters for the achievement of the goals and objectives of Sustainable Development.

These three factors are relevant to two kinds of policy formulation.

1. Legislative policy intended to achieve legislative goals and setting legislative objectives for industry.

2. Policy formulated in industry intended to achieve satisfaction of legislation.

The extent to which policy formulation can address each the three factors listed above is dependent on the kinds of laws established by legislative policy.

Laws could stipulate involvement with a particular recycling option for specified agencies or could stipulate targets the achievement of which may or may not involve recycling.

In the first case, the three listed factors should be considered during legislative policy formulation processes that stipulate recycling or an alternative to recycling.

In the second case, it is for policy formulation processes within targeted agencies to consider the three listed factors when pursuing options which may contribute to satisfaction of legislation.

This distribution of waste policy formulation between Legislative and Industrial Agencies is represented in Fig 3.1 which shows how Legislative Policy can seek to directly govern industrial processes and/or seek to empower and encourage Industrial Agencies to adopt environmentally streamlined waste practices.

The three main factors can be broken down and rephrased as seven questions relevant to research into recycling in the context of Waste Policy:

1. What are the goals and/or objectives which recycling could help satisfy?

This includes the goals and objectives which "Industrial" and "Legislative" Policies are directed at in Fig 3.1. Fig 3.1 assumes that these are related to "Consequences for Resource Use and Environmental Quality" for Legislative Agencies (based on Wolbeck's twin objectives of Sustainable Waste Policy p.32). For industrial agencies, the goals and objectives are assumed to be profit oriented and are thus related to "Costs and Benefits Appreciated by Industrial Agencies."

2. What are the contributions of recycling to achievement of identified goals and objectives?

It is assumed in Fig 3.1 that recycling can help improve "Resource Use and Environmental Quality". Inclusion of Industrial Agencies in the process of Waste Policy formulation and implementation also introduces their profit oriented goals and objectives. It is assumed in Fig 3.1 that Legislative Agencies can influence "Appreciation of Costs and Benefits by Industrial Agencies" as well as employing more traditional methods of intervention to directly influence implementation of options.

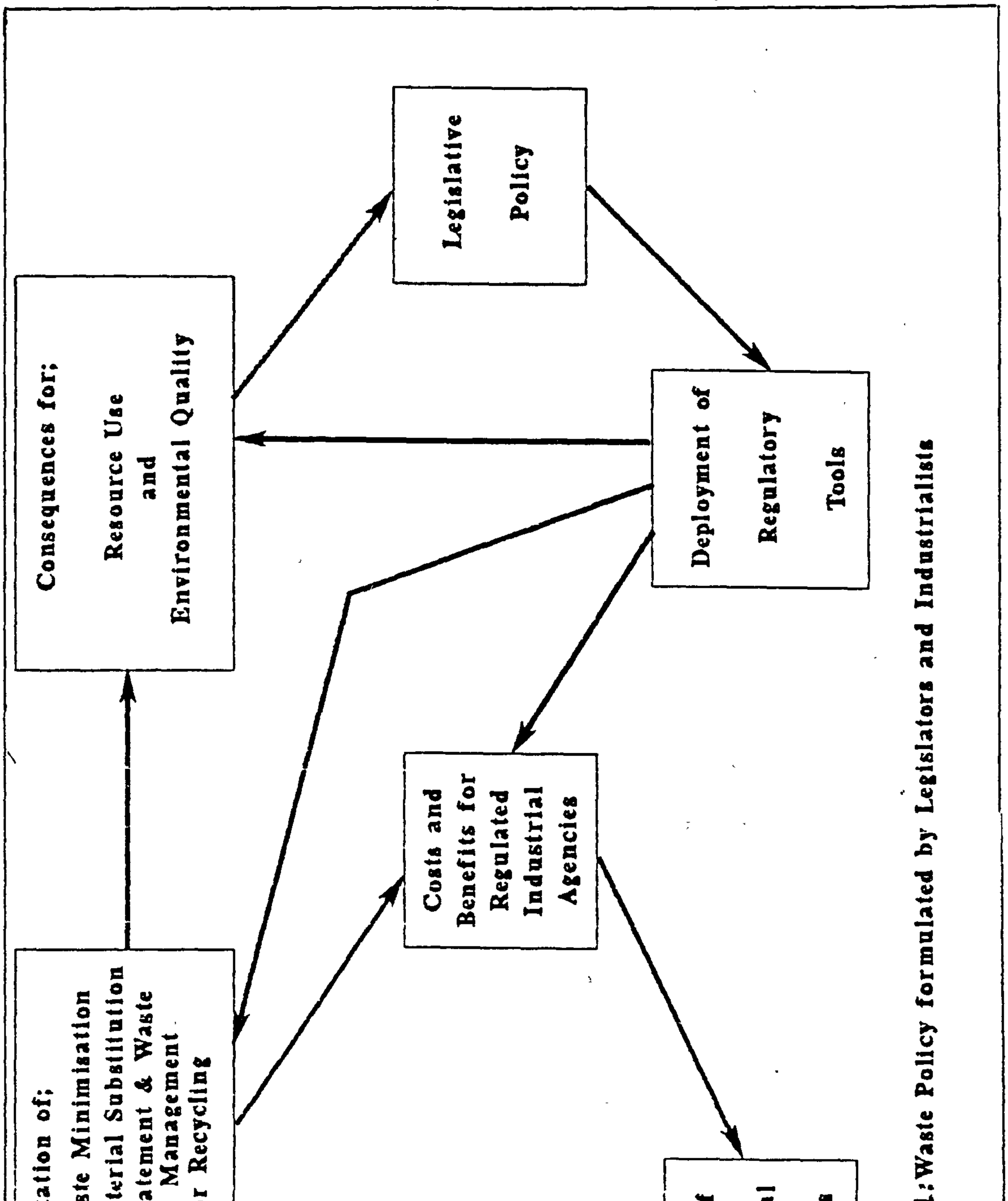


Fig 3.1: Waste Policy formulated by Legislators and

3. How is recycling promoted in order to contribute to satisfaction of identified goals and objectives?

Fig 3.1 represents the powers of Legislative Agencies in terms of "Deployment of Regulatory Tools." The methods by which Industrial Agencies may promote recycling is not represented in any detail.

4. What are the contributions of other options to achievement of identified goals and objectives?

It is assumed in Fig 3.1 that other options can help improve "Resource Use and Environmental Quality". The options are classified as "Waste minimisation, Material Substitution and Abatement and Waste Management" following Wolbeck (See p.32). It is assumed that these option types are similar to recycling in that they influence "Costs and Benefits Appreciated by Industrial Agencies" and "Consequences for Resource Use and Environmental Quality."

5. How are other options promoted in order to contribute to satisfaction of identified goals and objectives?

Other options are assumed to be subject to similar forms of intervention or consideration by Industrial Agencies as with recycling.

6. What are the differences between recycling and other options with respect to:

Contributions made to achievement of identified goals and objectives?

Measures taken to promote recycling and other options?

Fig 3.1 represents recycling and other options as subject to similar forms of regulation and consideration by Industrial Agencies and suggests that all options contribute to improvements in terms of "Consequences for Resource Use and Environmental Quality." The model as represented in Fig 3.1 lacks detail regard the option types, their particular contributions and the particular measures by which they are promoted.

Previous research has focused on differences in terms of national policy agendas. This research focuses on the differences appreciated by Industrial Agencies and what the consequences of such differences are at the national level now that Industrial Agencies are empowered to choose options. In terms of Fig 3.1, this question cannot be answered until additional detail is identified and incorporated into the model to distinguish the option types.

7. To what extent do differences between recycling and other options matter?

For Legislative Agencies, differences matter to the extent that "Consequences for Resource Use and Environmental Quality" achieved as a consequence of "Deployment of Regulatory Tools" do not satisfy the goals and objectives of "Legislative Policy."

Similarly, for Industrial Agencies, differences matter to the extent that "Costs and Benefits Appreciated by Industrial Agencies" achieved as a consequence of

"Implementation of; Waste Minimisation, Material Substitution, Abatement and Waste Management and/or Recycling" do not satisfy the goals and objectives of "Industrial Policy."

Differences between options (identified as a consequence of research to provide additional detail about the process of Waste Policy formulation and implementation) can be analysed in terms of congruence or incongruence between the satisfaction of goals and objectives of Legislative and Industrial Agencies.

3.3 Operationalising Research Questions

The questions posed in Section 3.2 remain open to interpretation. At the general level, however, these questions focus the research on the system by which legislative and industrial policies interact. A simple model of this system is shown in Fig 3.1. This model assumes two forms of legislative policy:

i) Direct intervention to prescribe industrial practices from the set of four option types (identified in Chapter 2):

Waste Minimisation
Material Substitution
Abatement and Appropriate Waste Management
Recycling

ii) Intervention which influences the costs and benefits accrued by industrial organisations according to their implementation (or not) of some combination of the four option types.

In Chapter Four it is shown that Environmental Legislation in the UK enables industrial agencies to exercise discretion over implementation of the four kinds of option identified. Direct intervention by current UK Legislative Agencies is limited to:

Subsidy for consultancy

Subsidy for "innovative" schemes

Regional planning agencies which may reject plans on the basis of "local demand" for a given kind of development.

This is represented in Fig 3.2 by the "weak" direct link from "Regulatory Laws" to "Implementation of Waste Options" in contrast to the "strong" link via "Impact on Organisational Costs and Benefits" and via "Organisational Waste Policy".

Fig 3.2 can be taken as a first approximation for a conceptual model of Waste Policy which shows how Policy Formulation is split between Legislative and Industrial Agencies. This model assumes that Industrial Agencies seek profit and that Legislative Agencies seek physical improvements which alleviate resource and environmental problems associated with industrial processes.

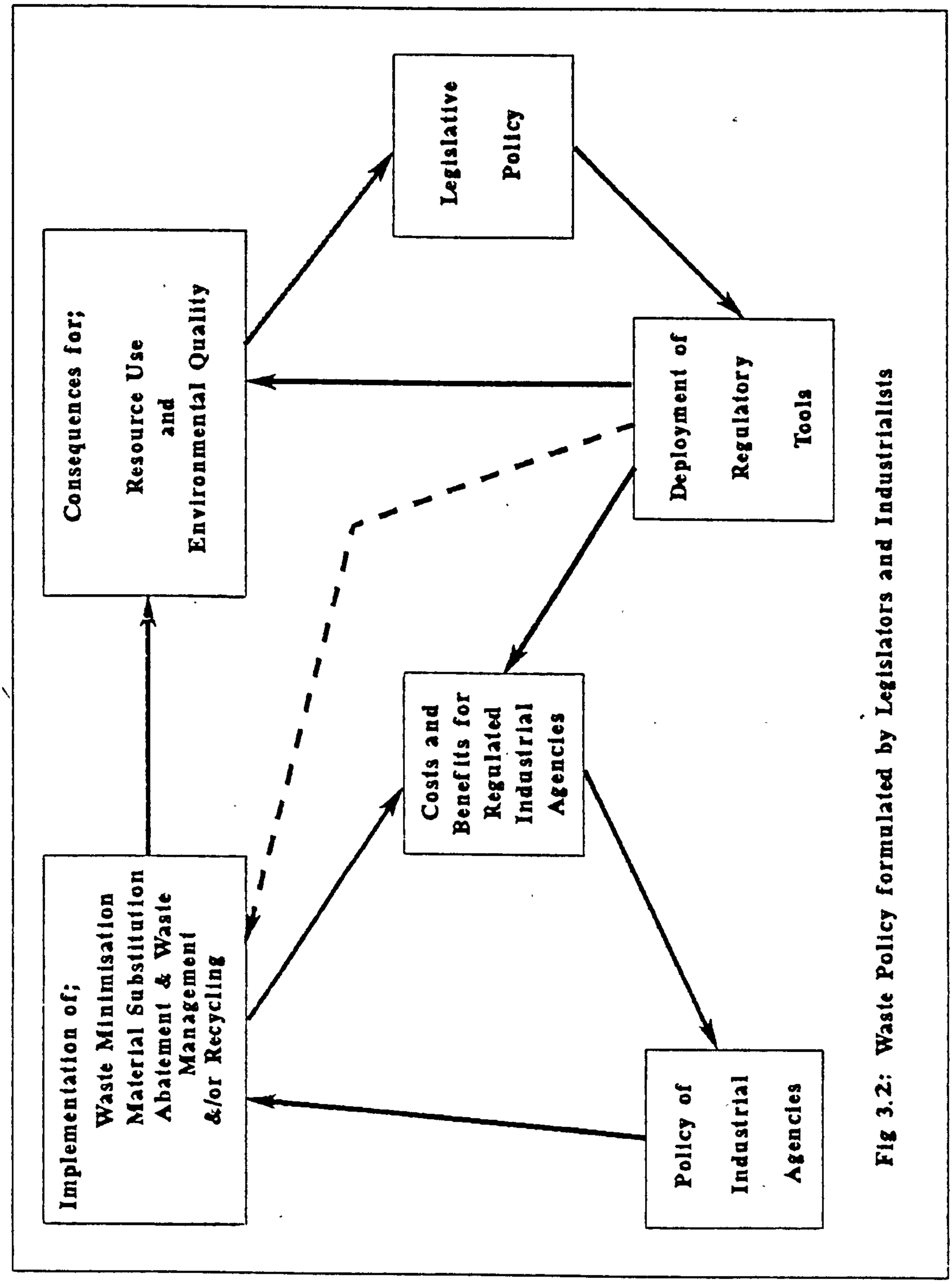


Fig 3.2: Waste Policy formulation

Some elements of Fig 3.2 could be quantified, for example:

"Deployment of Regulatory Tools" could be associated with a "Cost of Regulation"

"Consequences for Resource Use and Environmental Quality" could be associated with a "Value of Environmental and Social Benefit".

To construct such a model for research purposes would be to suggest that research could be conducted to evaluate these costs and values and that knowing them would improve understanding of the system.

On the other hand, Fig 3.2 presumes that the particular combination of "Waste Options" implemented by Industrial Agencies contributes to alleviating resource and environmental problems. There is no consideration of the processes by which options are considered and implemented and whether such processes generate a good blend of such options being pursued in industry.

To pursue this line of research involves iterative phases of model building and investigation. Model building enables processes to be postulated which could describe circumstances that enable the different options to be pursued. Investigation tests such postulations against observations and uncovered influences not accounted for by the model. Such contributory influences can then be incorporated into the next phase of model building. For example, replacing the strong link from "Deployment of Regulatory Tools" to "Implementation of Waste Options" with a weak link represents a first phase of research fed back into the model building process.

The conceptual model expressed in Fig 3.2 shows that policy formulation by industrial and Legislative Agencies are both key to understanding waste practice. In Chapter Two, "External Recycling" is defined as involving at least two Industrial Agencies. The research focuses on Waste Policy by considering the perspectives of Legislative and Industrial Agencies. The research is tailored to a recycling focus by considering issues from the perspectives of two kinds of Industrial Agency. The three perspectives from which issues are considered are:

Legislative
Waste Producer
Waste Manager

Other perspectives could be included such as Material Producer or Consumer. The particular perspectives selected for this research are sufficient to address Waste Policy issues including those associated with recycling as an option for Waste Managers. This focuses the research on the requirements of BCWM and on Waste Policy issues involving multiple agencies in order to address the kinds of issue arising from new forms of legislation. Although some issues for Waste Producers and Waste Managers arising from behaviour other agencies are identified in the research, these issues are not analysed from the perspective of those agencies. This would involve further research tailored to examination of other specific perspectives.

The seven questions derived in Section 3.2 can be further reduced in respect of the three perspectives chosen. This yields the following three sets of questions (essentially re-statements of one set of questions from different perspectives).

Legislative Questions (prefixed "L")

L1. What are the stated goals and objectives of environmental legislation in the UK to which recycling could contribute?

L2. What benefits of recycling industrial wastes are recognised by legislators as contributory to achievement of legislative goals and objectives?

L3. What legislative mechanisms are intended to encourage recycling of industrial waste in the UK?

L4. What benefits of other industrial options are recognised by legislators as contributory to achievement of legislative goals and objectives?

L5. What legislative mechanisms are intended to encourage other options which contribute to the achievement of environmental goals and objectives in the UK?

L6. What are the differences between recycling and other options with respect to:

(a) achievement of the stated goals and objectives of environmental legislation in the UK?

(b) legislative mechanisms intended to encourage each kind of response in the UK?

L7. Under what circumstances do differences between recycling and other options matter for the satisfaction of legislative goals and objectives and for responses encouraged by legislative mechanisms used?

Waste Producer Questions (Prefixed "P")

P1. What are the goals and objectives of industrial waste producers to which recycling could contribute?

P2. What benefits of recycling industrial wastes are recognised by waste producers as contributory to achievement of their goals and objectives?

P3. What mechanisms are deployed to implement recycling of industrial waste by waste producers?

P4. What benefits of other industrial options are recognised by waste producers as contributory to achievement of their goals and objectives?

P5. What mechanisms are deployed by waste producers to implement other options?

P6. What are the differences between recycling and other options with respect to:

(a) achievement of stated environmental goals and objectives of waste producers?

(b) knowledge skills and resources deployed to implement each kind of response by waste producers?

P7. Under what circumstances do differences between recycling and other options matter to waste producers for the satisfaction of environmental goals and objectives and for implementation of responses?

Waste Manager Questions (Prefixed M)

M1. What are the goals and objectives of industrial waste managers to which recycling could contribute?

M2. What benefits of recycling industrial wastes are recognised by waste managers as contributory to achievement of their goals and objectives?

M3. What mechanisms are deployed to implement recycling of industrial waste by waste managers?

M4. What benefits of other industrial options are recognised by waste managers as contributory to achievement of their goals and objectives?

M5. What mechanisms are deployed to implement other options which contribute to the achievement of environmental goals by waste managers?

M6. What are the differences between recycling and other options with respect to:

(a) achievement of stated environmental goals and objectives of waste managers?

(b) knowledge skills and resources deployed to implement each kind of response by waste managers?

M7. Under what circumstances do differences between recycling and other options matter to waste managers for the satisfaction of environmental goals and objectives and for implementation of responses?

Fig 3.3 is tailored to consideration of Waste Producers and Waste Managers by considering each as individual systems interacting through market mechanisms. Other kinds of industrial organisations (such as Material Suppliers) could be included at similar levels of detail, but are in this case reduced to representation as "Other Industrial Agencies".

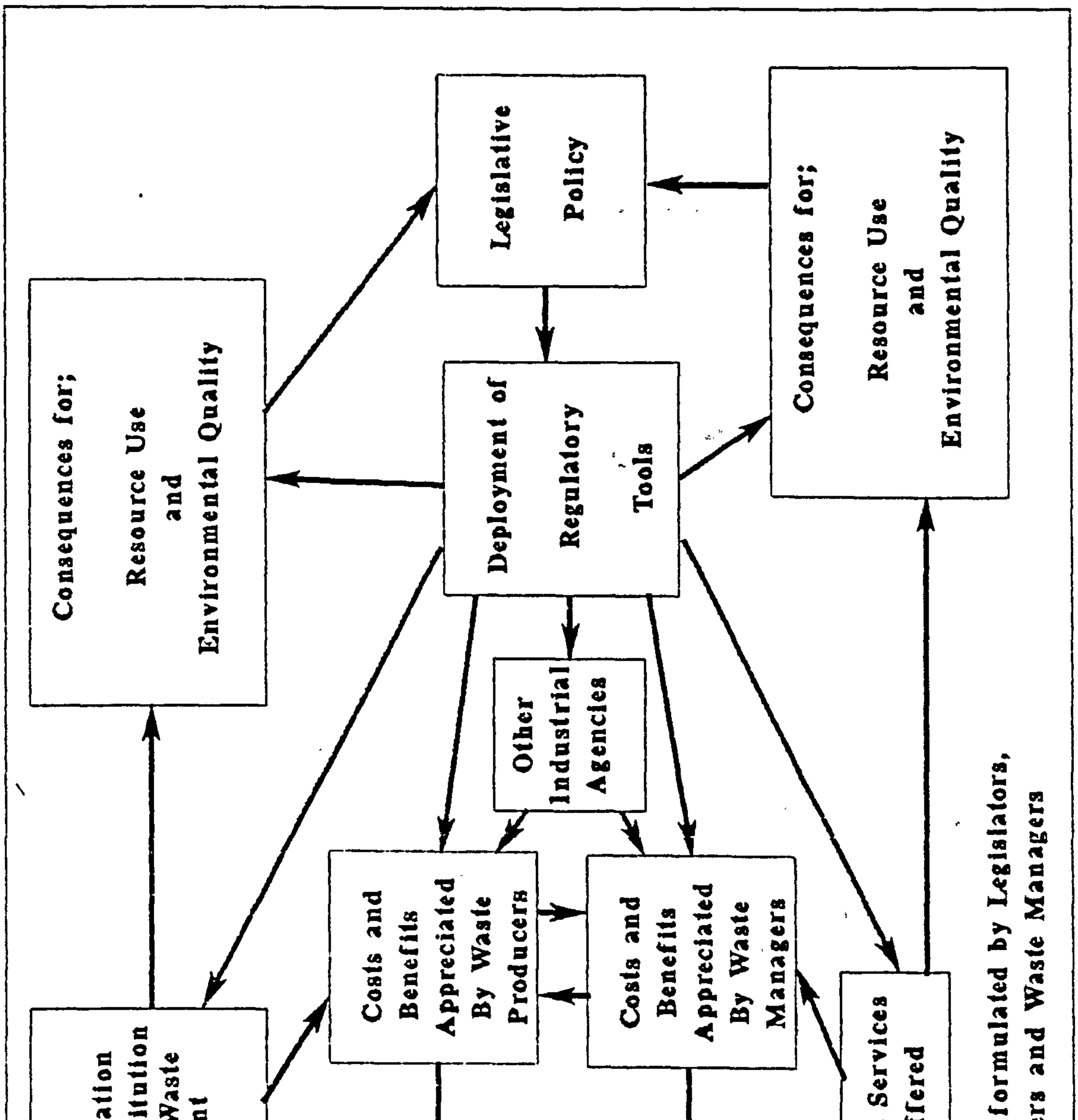


Fig 3.3: Waste Policy formulated by Legislators, Waste Producers and Waste Managers

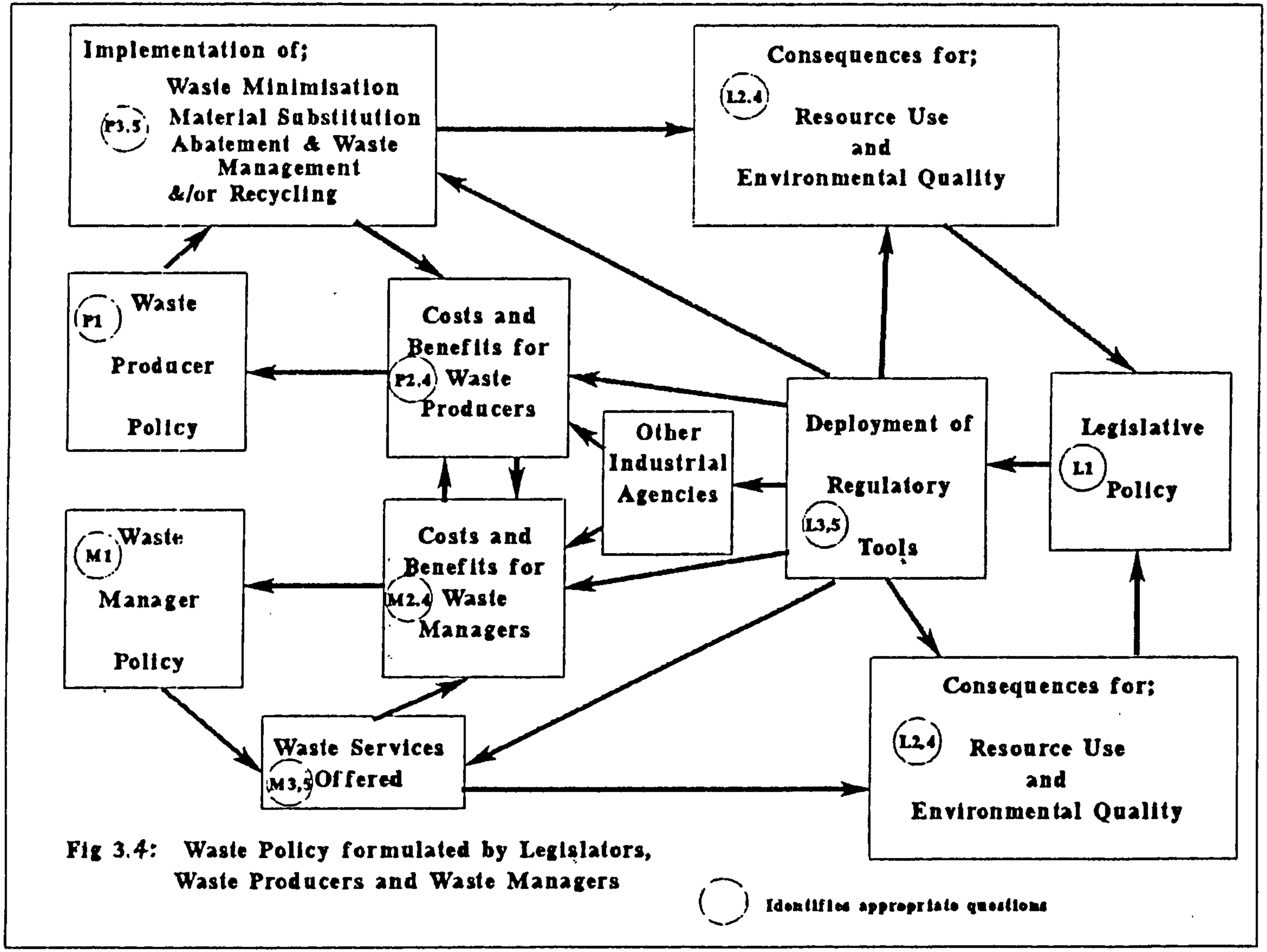


Fig 3.4: Waste Policy formulated by Legislators, Waste Producers and Waste Managers

Fig 3.4 correlates the research questions (above) with model elements. The research questions can be considered as tools to improve understanding of particular model elements and the linkages between them.

3.4 First Phase Research Activity

The Conceptual model represented in Fig 3.3 indicates that the interests of BCWM do not account for some broader aspects of Waste Policy formulation which include;

> How "Legislative Policy" is formulated according to goals and objectives over and above promoting changes to waste management practice as experienced by BCWM.
>
> How "Deployment of Regulatory Tools" influences "Implementation of; Waste Minimisation, Material Substitution, Abatement and Waste Management, and/or Recycling," by "Waste Producers."
>
> How "Waste Producer Policy" is formulated in the light of "Costs and Benefits Appreciated by Waste Producers" due to implementing changes to meet regulatory requirements and due to market forces influencing supply of waste management services and influencing "Other Industrial Agencies" such as material suppliers.
>
> How "Consequences for Resource Use and Environmental Quality" arising from changes implemented by Waste Producers and Waste Managers are taken into account by "Legislative Policy" and how further "Deployment of Regulatory Tools" may arise as a consequence.

The objective of the first phase of research is to develop an understanding of, the linkages between and the detail of, elements of the conceptual model which fall outside of the established interests of BCWM. These linkages can be considered as two separate systems called **"System 1"** and **"System 2"** below.

System 1 includes the feedback loop identified in Fig 3.3 between "Legislative Policy", "Deployment of Regulatory Tools" and "Consequences for Resource Use and Environmental Quality". This system is shown in Fig 3.5. System 1 takes "Monitored Changes" as inputs and generates "Regulatory Mechanisms" as outputs.

Research into the behaviour of System 1 starts from the principle that the legislative process involves a hierarchy of agencies. Such agencies establish Legislative Policy according to stipulation of new laws and reference to precedents established by old laws. In democratic countries, the highest level agencies are Governments empowered by the electorate. Governments empower and monitor subsidiary agencies which in turn empower and monitor lower level agencies. At the lowest levels regulatory tools are deployed and changes are monitored (not necessarily by the same agencies).

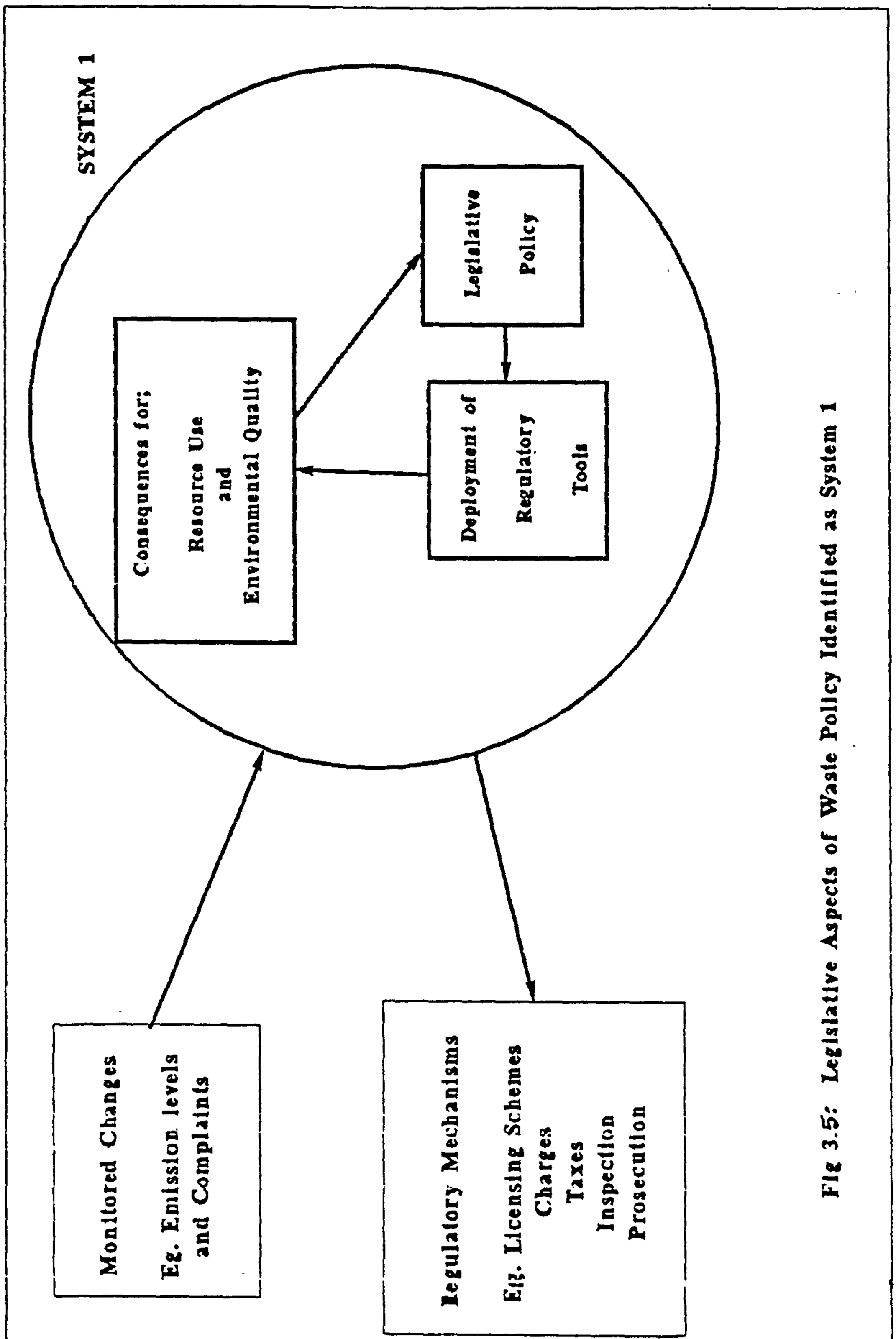


Fig 3.5: Legislative Aspects of Waste Policy Identified as System 1

Research to uncover detail about the elements of System 1 and the linkages between them could involve;

A review of literature sources

Consultation with legal advisers

Consultation with people involved in the process represented by System 2

It was thought that consultation with legal advisers would involve payment if considerable time was to be demanded of them. Such expenditure was not justified until other avenues of research had been explored. In the end, sufficient detail was uncovered using other approaches, removing the need to resort to consultation with legal advisers.

Attempts were made to establish contact with people at the "Department of Environment" and "Her Majesty's Inspectorate of Pollution" by telephone. Although the model identified general areas where detail was required, it did not enable identification of particular problems and issues to request information about. Identifying such problems and issues is part of the research intent. Although staff were contacted in the above organisations, they tended to be specialists who recommended other specialists a soon as the conversation moved away from their immediate field of specialism. It was apparent that this line of research would require a great deal of effort in order to assemble a complete picture of legislative issues on the basis of diverse and specialised reports.

Attempts to interview staff in Legislative Agencies were aborted since review of literature sources was proving more productive in terms of identifying relevant issues and detail of legislative procedures intended to address those issues. Due to the topical nature of new legislative processes, there is a wealth of published material addressing the kinds of issues which the research seeks to explore..

The investigation then, focuses strongly on literature sources and legislative documents. This review of legislation seeks to identify Legislative Agencies within a hierarchy. At each level conditions of empowerment passed down the hierarchy and monitoring information passed up the hierarchy are analysed in terms of the kinds of actions agencies are empowered to take in response to monitoring information received.

Findings of subsequent research activities are described in Chapter Four:

Sections 4.2 to 4.4: A review of European Community (EC) legislation and policy formulation to identify;

A Hierarchy of European Legislative and Regulatory Agencies empowered by national governments

Legislative mechanisms which European Agencies are empowered to deploy to empower and monitor Member States

Established principles of Environmental Legislation employed by European Agencies

Sources include

The "Treaty of Rome"

The "Single European Act"

European "Directives"

"EEC Environmental Policy and Britain" (Haigh 1987)

Sections 4.5 to 4.7: A review of UK legislation and policy formulation to identify;

Cases of EC environmental policy influencing UK environmental policy

Cases of UK environmental policy influencing EC environmental policy

A Hierarchy of UK Legislative Agencies empowered to regulate "Waste Producers" and "Waste Managers"

Regulatory mechanisms which UK agencies are empowered to deploy to regulate and monitor "Waste Producers" and "Waste Managers"

Established principles of environmental regulation employed by UK agencies

Sources include;

Reports of "The Royal Commission On Environmental Pollution" (RCEP) and published responses of the UK Government

"The Environmental Protection Act" (1990)

Annual Reports of Her Majesty's Inspectorate of Pollution

Papers from "Integrated Pollution Control: A Practical Guide For Managers" (O'Riordan 1992).

This research activity was also generally informed by attendance of the "European Community Environmental Legislation" conference organised by "IBC Legal Studies & Services Ltd" in association with "The United Kingdom Environmental Law Association" (10 July 1991).

The output of this research is twofold:

Firstly it enables the kinds of regulatory and monitoring mechanisms generated by Legislative Agencies at the lowest level of the hierarchy to be identified. In the case of environmental regulation of industry, these mechanisms can be categorised as:

Exposure Standards
Environmental Quality Standards
Emission Standards
Process Standards
Market Mechanisms

(Haigh 1987)

Secondly it enables a rationale to be identified according to which changes to "Deployment of Regulatory Tools" may be made in response to monitored "Consequences for Resource Use and Environmental Quality." For example standards may be tightened, new monitoring requirements stipulated or taxes increased (a market mechanism).

This output is expressed in Section 4.8 in terms of the seven "Legislative" research questions outlined in Section 3.2.

System 2 includes the feedback loop identified in Fig 3.3 between "Waste Producer Policy", "Implementation of; Waste Minimisation, Material Substitution, Abatement and Waste Management and/or Recycling" and "Costs and Benefits Appreciated by Waste Producers." This system is shown in Fig 3.6. System 2 takes "Regulatory Mechanisms" and "Market Forces" as inputs and generates "Resource Use and Environmental Effects" and "Market Forces" as outputs.

Research into the behaviour of System 2 starts from the principle that Waste Producers seek to maximise profit from their business activities. The activities firms can pursue to make profit are limited by regulatory mechanisms and market forces. This gives rise to issues concerning;

How much and what kinds of environmental improvement must be pursued according to regulatory mechanisms?

How much and what kinds of environmental improvement are encouraged by market forces?

How much and what kinds of environmental improvement can be achieved by implementing different kinds of option?

How can different kinds option be implemented and how much do they cost?

Investigation of the behaviour of System 2 focuses on finding out how firms ("Waste Producers" in Fig 3.6) perceive and resolve these issues. Possible starting points for such an enquiry include;

interviewing staff in waste producing firms, possibly exploiting BCWM's customer network,

sending questionnaires to many waste producing firms which focus on issues relevant to Waste Policy formulation and implementation,

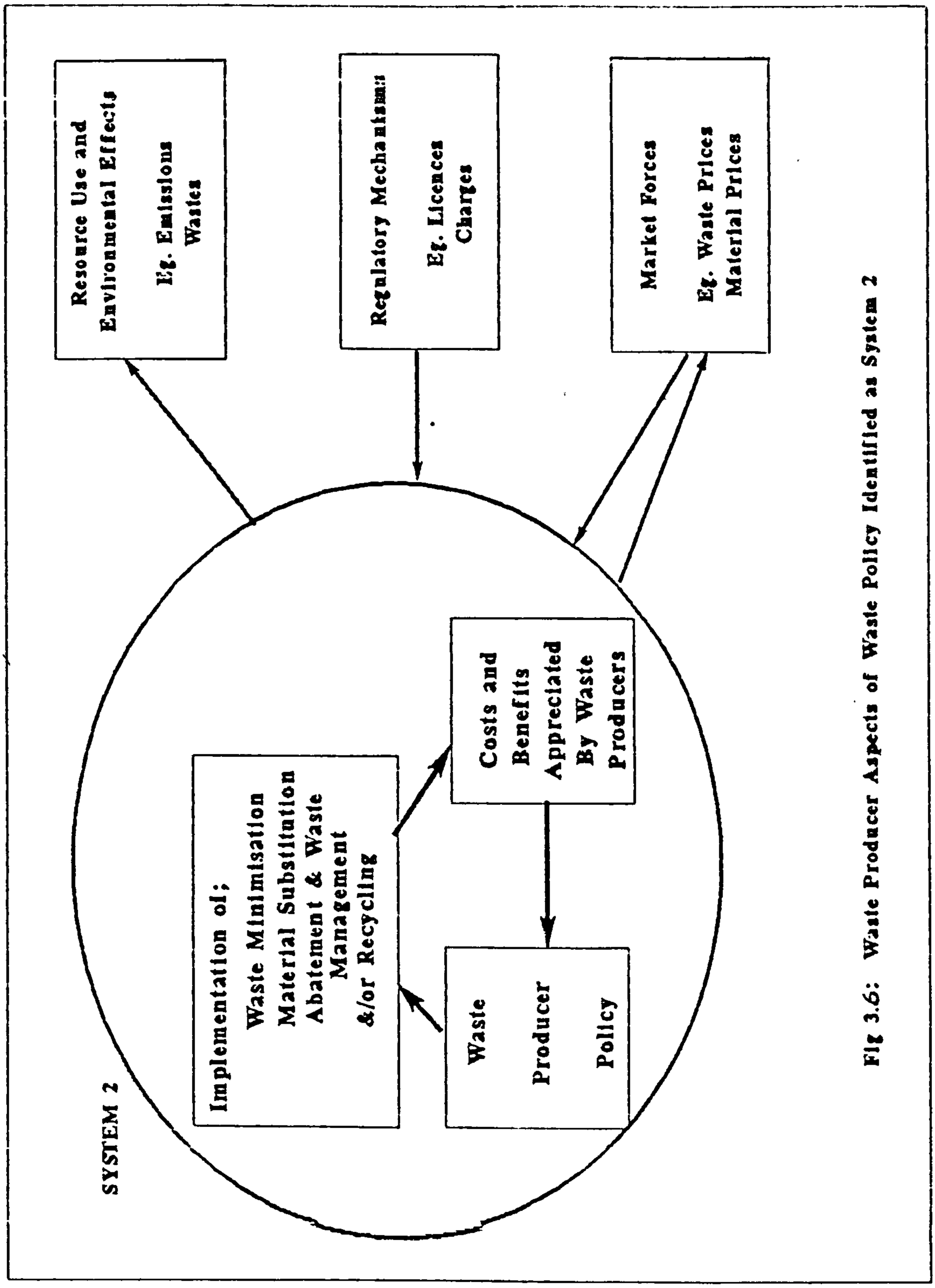


Fig 3.6: Waste Producer Aspects of Waste Policy Identified as System 2

reviewing literature on the subject of Waste Policy formulation and implementation in firms,

consulting with specialists that advise firms on Waste Policy formulation and implementation.

It was thought that interviewing staff in waste producing firms would be time consuming since many firms would have to be surveyed involving interviews with several staff in each firm if the research was to be broad based in terms of covering issues faced by different kinds of firm and different departments within firms. This option is better suited to identifying issues faced by Waste Producers in the case study conducted in Phase Two of the research since only one kind of Waste Producer needs to be considered.

Questionnaires could be sent to many firms and addressed to different kinds of personnel. However, questionnaire design requires prior knowledge of the issues to be addressed if the questions posed are to be precise enough to enable comparison of results. This avenue of research was kept open in case specific issues were identified that required further clarification. In the end though alternative approaches generated sufficient information to inform the conceptual model for the purposes of this research project. A questionnaire approach would be appropriate for further research focused on issues directly relevant to Waste Producers over and above simply understanding the kinds of conditions that influence waste production. Although such research could provide more detail and enhance the understanding of detail presented in this thesis, the process of surveying by questionnaire is time consuming and was not pursued in the interest of spending time on Phase Two of the research.

Literature sources regarding industrial aspects of Waste Policy formulation and implementation tends to focus on research conducted in the USA and other countries where similar (but not identical) changes to environmental legislation have occurred. Although such literature provides some understanding of the kinds of issues faced by firms in the UK, it is difficult to identify which aspects of the UK and American experiences are analogous and which aspects would be misleading if they are assumed to be analogous. Comparison of Waste Policy formulation and implementation in the UK and the USA would be an informative exercise. However such an exercise would involve a detailed exploration of American legislative processes as well as a review of research undertaken into industrial aspects of waste issues. This thesis does not present literature of this kind because this line of enquiry was not developed in the interest of spending more time on other research activities.

Recent changes to environmental regulation have given rise to a growth in environmental consultancy in the UK. Environmental consultants seek to profit from helping firms resolve issues including those involved with waste. Environmental consultants operate by interviewing staff at all levels in client firms. Client firms are often from diverse sectors of industry. Interviewing environmental consultants seemed to be an appropriate method of investigating System 2 in terms of the breadth of information which could be acquired and in terms of efficient use of time. One consultant can report issues perceived by staff performing a diversity of roles in a diversity of firms.

It is shown in Chapter Five that eliciting information from environmental consultants regarding technical problems, strategic issues, and impact of regulatory mechanisms experienced by their clients generates a rich picture of how firms perceive and resolve issues associated with Waste Policy formulation and implementation.

The research method, presented in Section 5.2 involves a soft survey approach to elicit a rich picture of issues faced by the clients of environmental consultants. IE. interviews with consultants were conducted as conversations with topics introduced to focus the conversation on issues relevant to Waste Policy formulation and implementation.

The output of this research is threefold:

> Firstly it enables the aspects of regulatory mechanisms and market forces appreciated as costs and benefits by "Waste Producer" firms to be identified.
>
> Secondly, it enables the kinds of environmental improvements and market forces which "Waste Producer" firms can generate, by implementing changes, to be identified.
>
> Thirdly it enables rationales to be identified according to which "Implementation of Waste Minimisation, Material Substitution, Abatement and Waste Management and/or Recycling" is pursued in response to "Costs and Benefits Appreciated by Waste Producers."

This output is expressed in Section 5.4 in terms of the seven "Waste Producer" research questions outlined in Section 3.2.

Phase 1 of the research is concluded by using the research findings presented in Chapters Four and Five to improve the conceptual model represented in Fig 3.3. The model is improved by more detailed modelling of linkages between model elements or of the model elements themselves. The model may also be improved by restructuring linkages or adding, removing or replacing model elements.

Rather than enabling further development of the conceptual model, some research findings contribute information about different conditions which influence the behaviour of the systems modelled. Such conditions are a fact of the real world which must be bourne in mind when using the conceptual model as an aid to understanding the system modelled. Research findings of this kind are simply summarised alongside appropriate considerations for understanding how the conceptual is limited in representing the real world.

Further development of the conceptual model is presented in Chapter Six. Such development is shown to address the research questions posed in Section 3.2.

3.5 Second Phase Research Activity

Blue Circle Waste Management Ltd (BCWM) have a direct interest in recycling as a possible alternative to established waste management practices. BCWM's interest arises from a preference to operate viable recycling operations than to compete with them. During the later stages of the research project, BCWM's Managing Director expressed a desire for the research project to be directed at considering how to assess the viability of recycling opportunities for BCWM.

In the absence of mandatory requirements to recycle, the viability of any recycling operation depends largely on financial factors.

To the author's knowledge, no single means of assessing recycling has been identified which exhaustively accounts for all possible properties of materials, processes and markets. Rather than attempt to achieve such a feat, one particular recycling option and ways to assess its viability are investigated. Aspects of the investigation which have more general application can then be identified.

This investigation is informed by;

the conceptual model as presented in section 3.2 and developed in Chapter Six

knowledge of waste management activities and concerns developed by close involvement with BCWM

information supplied by BCWM

further research presented in Chapters Seven through Nine and which is outlined below.

In consultation with BCWM, a researchable recycling option of interest to BCWM was identified. This option is to recycle "builders' skip waste" at a landfill site for use as "cover material" and "hardcore" on site.

"Cover material" is material used to cover the working face of a landfill site at intervals during a working day and at the end of a day. Covering the working face is a mandatory requirement and it also helps to prevent problems associated with pests, windblown litter and escaping "smells" of concern to local residents. "Cover material" is any "inert" material which can be used for this purpose, such as soil, sand or gravel.

"Hardcore" is any material used at landfill sites to construct temporary roads on the covered landfill to provide access for waste delivery vehicles to the landfill working face. "Hardcore" is any "inert" material which can be used for this purpose, such as rubble or aggregates.

"Builders' skip waste," is any skip load of waste which is likely to contain material suitable for recycling into cover material or hardcore. Such waste is likely to arise from construction or demolition activities and is usually described as "builder's waste" on waste transfer notes. Construction and demolition waste accounts for about 25% of waste sent to landfill in the UK.

This option is of interest to BCWM because of the immediate use which can be made of the recycled materials in their business.

In this case, the recycling option involves two primary industrial agencies;

construction firms as "Waste Producers"

BCWM as "Waste Managers" for wastes that are landfilled

BCWM are also the potential recyclers and final users of recycled products

Waste Hauliers are identified as playing a role although their interests and concerns were not researched in depth. Waste Hauliers can be considered as "Other Industrial Agencies" in terms of Fig 3.3.

Further development of the conceptual model in Chapter Six shows that some aspects of "Waste Producer" behaviour depend on the particular situations of waste producing firms. Research was conducted to investigate which particular aspects apply to "Waste Producers" in the construction sector.

This research involves surveying a construction firm that has made considerable efforts to consider waste issues in the construction sector and that is progressive in its response to regulatory mechanisms and market forces. Initial contact was established with the Quality Manager of this firm following the interviews of environmental consultants in Phase One of the research project. A meeting had been arranged by telephone. Summaries of this meeting and consequent meetings with other staff in the firm are presented in Chapter Seven.

Although other firms could be surveyed using interviews or questionnaires, the firm initially contacted seemed to have considerable depth of knowledge concerning waste issues in their sector. The Quality Manager who was interviewed at length is a specialist in this field (recognised as such by respondents amongst the environmental consultants interviewed in Phase One of the research) and he continually scans waste practices pursued in other firms using trade journals and contacts in the industry. Given this access to expert knowledge, it seemed inefficient to devote considerable time in an effort to identify limitations of this source.

The output of this research activity is two-fold:

Firstly, it enables the considerations of a particular "Waste Producer" to be compared with the conceptual model as presented in Chapter Six. This is done by showing how the research findings address the seven "Waste Producer" research questions and comparing the information with similar information presented in Chapter Six.

Secondly it provides information about the wastes produced by construction firms and conditions which enable or prevent change to wastes arising. In other words it provides information about current, and likely future demand aspects of "Market Forces" experienced by BCWM as suppliers of waste management services to the construction sector.

Waste Hauliers play a role in transmitting market forces between waste producers and waste managers. Some of the evidence presented in Chapter Seven suggests that Waste Hauliers to the construction sector do not perform this function well. It is also reported in Chapter Eight that Waste Hauliers are unwilling to discuss how they pass on costs of waste management to their customers.

In the absence of direct information, a modelling tool is derived in Chapter Eight to represent the role of Waste Hauliers as intermediaries. This tool considers one waste facility in the context of the nearest waste facilities with which it competes. It is shown that for given sets of waste prices charged per tonne at these facilities, and for given waste transport costs per tonne per mile, that a "catchment area" can be determined for the facility considered.

"Catchment area" is an abstract concept which represents a geographic area around a waste facility from within which wastes are brought to the facility. The modelling tool derived assumes that Waste Hauliers behave to minimise the cost of each trip performed and according to a set of assumptions which are required to derive the tool from mathematical principles.

The tool is used a spreadsheet model and applied to BCWM's Beddingham Landfill Site. Catchment areas are derived for various wastes brought to the site in skips. Research conducted to acquire appropriate data for this model is also presented in Chapter Eight.

The model output was compared with BCWM's conceptions of Beddingham Landfill's catchment to identify limitations of the model.

The calculating model is also applied to generate a graph showing how catchment area varies according to prices charged at Beddingham Landfill, and transport costs per tonne per mile. These results are used in a separate modelling activity which is presented in Chapter Nine.

Chapter Eight also explores some more qualitative uses of the modelling tool. It is shown that this tool can be used to consider;

> Some consequences in terms of catchment area for Waste Managers demanding waste which is separated at source
>
> Ways in which different forms of pricing policy adopted by Waste Managers can generate different kinds of catchment area

Having considered relevant aspects of waste production and waste haulage for construction wastes, it is possible to investigate the particular option to recycle construction waste into cover material and hardcore at landfill sites. It is shown in Chapter Seven that construction waste is likely to continue to arise in skip loads. The modelling activity presented in Chapter Eight enables estimates of increased throughput due to changing prices charged for skip waste to be made. Chapter Nine builds on these findings to assess the particular option of recycling "builders waste" and extrapolates the findings in terms of more general waste issues in the construction sector and in other sectors of industry.

Chapter Nine presents a detailed description of a recycling plant which performs the recycling activity to be assessed. One such facility already operates about two miles from Beddingham Landfill Site.

To consider the viability of a similar operation at one of BCWM's facilities a calculating model is developed which uses the economic concept of Net Present Value to asses the benefits of recycling at landfill sites.

It is more usual to also assess the costs of recycling. However, a method is developed which enables capital and operating costs for the recycling operation to be considered as model output. It is shown that using a spreadsheet model, values of these costs which make the recycling operation equally preferable to the null option (continuing to landfill wastes without recycling) can be determined. Such values are determined for various values of other parameters.

This approach is adopted for the following reasons;

Data for recycling costs is poor.

BCWM are more interested in the viability of recycling in general rather than how much profit a particular recycling operation installed at a particular landfill site generates. By running the model many times to account for different conditions represented by model variables, some of the conditions which influence the viability of this recycling option are analysed.

The aspects which this particular recycling option shares with other options can then be discussed and the consequences of the modeling activity for other similar options identified.

3.6 Summary

This chapter presents the conceptual model of Waste Policy formulation and implementation as an extension of previous research into recycling and Waste Policy into the domain of modern industrial regulation (Section 3.2). However, the conceptual model is an approximation which lacks detail concerning the conditions and decision criteria applicable to the agencies whose roles the model represents.

A first phase of research is proposed to investigate and represent missing detail. This research involves activities selected as contributory to understanding Waste Policy formulation and implementation on the basis that they explore conditions and decision criteria applicable to agencies identified as playing a role in the process as modelled in Section 3.3. Furthermore activities are selected for pragmatic reasons that limit the investigation to consideration of two kinds of industrial agency only (Waste Producers and Waste Managers) and which limit activities to those which identify relevant detail quickly and cheaply.

A set of questions is developed which enable research findings to be interpreted systematically. These questions focus interpretation on detail which informs the

conceptual model as an aid to understanding Waste Policy formulation and implementation as it occurs in the new regime of interaction between Industrial and Legislative Agencies.

A second phase of research is proposed to consider specific problems and issues associated with a particular recycling option. Prior development of the conceptual model and identification of detail applicable to more general Waste Policy issues and problems enables the findings of Phase Two to be analysed in a more general context.

Phase Two of the research maintains a broad focus appropriate to consideration of recycling by including investigation of conditions and decision criteria relevant to Waste Producers as well as Waste Managers. Waste Hauliers are also considered as intermediary agencies.

The methods and findings of these research activities are presented and analysed in Chapters Four to Nine below.

CHAPTER FOUR

Exploring Environmental Legislation and the Regulatory Environment

*But tho' nations in this particular resemble individuals, yet as they are different in other respects, no wonder they regulate themselves by different maxims, and give rise to a new set of rules, which we call the **laws of nations**."*

(D. Hume 1740; "A Treatise of Human Nature" Book III, Part II, Section XI)

4.1 Introduction

Environmental legislation in the UK changed significantly after the publication of the Environmental Protection Act (1990). This Act and consequent legislation differed from previous legislation in the following ways:

> Legislation moved away from prescription of process standards to address particular environmental concerns (command and control approach) and towards encouragement for industry to pursue improvements innovatively (using Market Based Instruments).
>
> Part I of the Act transferred resoponsibility for funding remediation monitoring and prevention of pollution was transferred from government to industry according to the "Polluter Pays Principle".
>
> In Part II of the act, much responsibility for waste management was transferred from local authorities to private firms coupled with improvement of process standards for waste management processes.

The consequences of such changes for industrial recycling of wastes can only be judged alongside the objectives of these legislative changes and the contribution of recycling and other options towards these objectives.

This chapter presents research undertaken to explore the intentions of environmental legislation and the possible contributions of recycling and other options in this regime.

Preliminary research was undertaken into the particular style and nature of environmental legislation and regulation within the UK (a member state of the European Community). This research was conducted to improve understanding of how "Legislative Policy" accounts for "Monitored Changes" in terms of "Consequences for Resource Use and Environmental Conservation" and empowers Regulatory Agencies to "Deploy Regulatory Tools" by employing "Regulatory Mechanisms." This process was identified in Section 3.3 as "System 1" as represented in Fig 3.5 (shown below for easy reference).

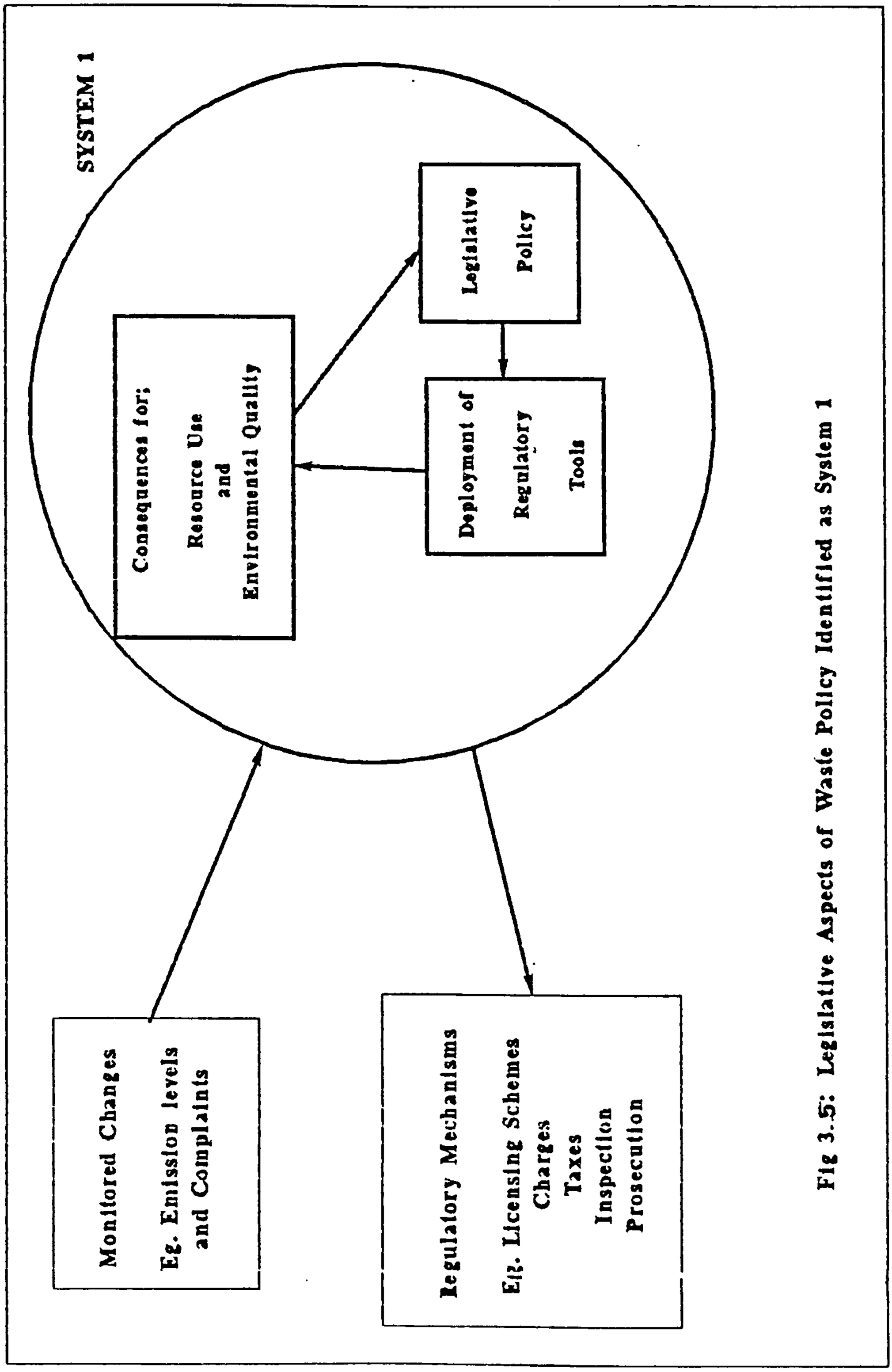


Fig 3.5: Legislative Aspects of Waste Policy Identified as System 1

The objectives of this research are:

> To identify regulatory tools deployed in the UK to regulate waste production and waste management and the regulatory mechanisms employed to implement them
>
> To trace legislative acts empowering regulatory agencies to deploy such tools and identify underlying the objectives and principles.
>
> To identify monitoring provisions by which consequences for environmental and resource conservation are fed back into legislative policy formulation
>
> To identify agencies responsible for legislative aspects of waste policy formulation and the means by which such agencies are empowered or empower others.

Environmental legislation sets standards for industry and empowers regulatory authorities to enforce, enable and monitor the meeting of such standards. A taxonomy of regulatory tools can be considered which apply to different realms of environmental concern.

> Exposure standards
> Environmental quality standards
> Emission standards
> Process standards
> Market based instruments
>
> (Haigh 1987)

"Exposure standards"

> apply to defined targets in the environment such as humans, salmon or waterfowl. Standards are set for maximum concentrations of toxins which are considered as hazards to health in a given organism. Eg. Directive 83/477/EEC sets limits on asbestos exposure for workers.

"Environmental quality standards"

> apply to defined environmental media such as air, water, land and specified geographic areas. Standards are set for concentrations in the media and may be based on relevant exposure standards for targets exposed to the media. Eg. Directive 79/923/EEC sets quality objectives for shellfish waters.

"Emission standards"

> apply to defined industrial processes such as power stations or paper and board manufacturing. Standards are set for concentrations at the point of release into a given media, based on limits for given types of process or on consents from authorities responsible for environmental quality standards. Eg. Directive 88/609/EEC limits emission of SOx and NOx from new, large combustion plants.

"Process standards"

apply to defined industrial processes. These standards stipulate particular plant equipment or materials to be employed (or banned) in particular processes. Examples include guidelines to determine chimney stack heights or paper bleaching and washing techniques.

"Market based instruments"

are tools intended to make certain activities cheaper or more expensive for anyone conducting such an activity. The range of tools commonly deployed includes;

Subsidy
Taxation
Charging Schemes
Deposit refund schemes

Examples include road tax and subsidy for innovative developments in industry.

This research involved three phases:

Review of EC legislation and policy formulation (Sections 4.2, 4.3, 4.4, and 4.5)

Review of UK legislation and policy formulation (Sections 4.5, 4.6, 4.7 and 4.8)

Attendance of the "European Community Environmental Legislation " conference organised by "IBC Legal Studies & Services Ltd" in association with "The United Kingdom Environmental Law Association" (Generally relevant to all sections)

In Section 4.9 the research findings are expressed in terms of the research questions posed in Chapter 3 and in terms of the conceptual model, the relevant elements of which are represented in Fig 3.5.

4.2 Legislative Developments Within the European Community (EC)

The EC was founded by the signing of the Treaty of Rome (1973).

Part 5 of the Treaty sets out the institutions of the community and their powers. The institutions are -

The Parliament
The Commission
The Council
The Court of Justice
The Economic and Social Committee

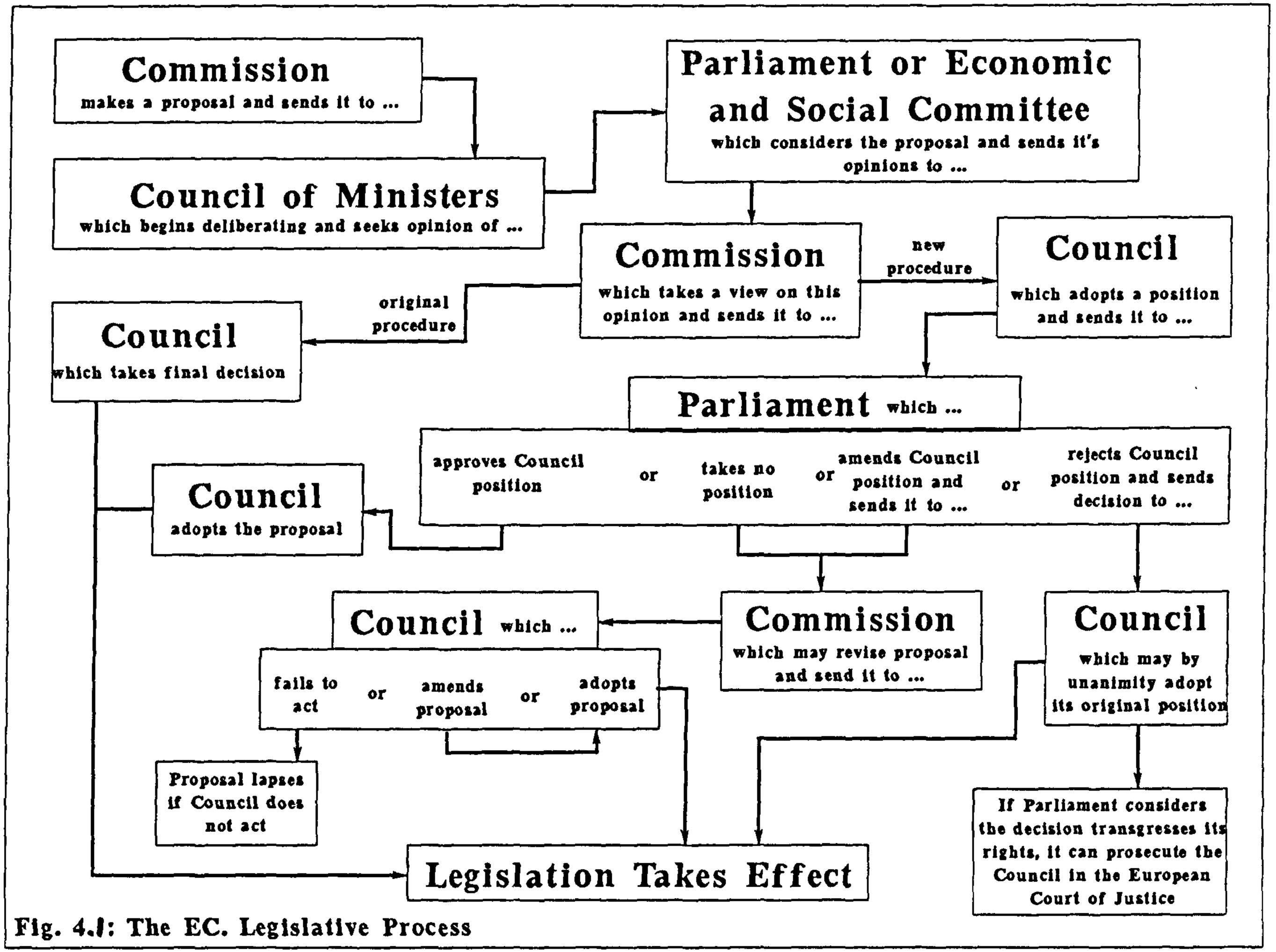


Fig. 4.1: The EC. Legislative Process

The original and current procedures for formulating legislation in the EC are shown in Fig 4.1.

The more recent "co-operative" legislative process enables the European Parliament to send proposals back to the Council of Ministers a second time (which may delay legislation taking effect). This is not likely to influence a Council determined to pass a particular item of legislation. The Parliament may be considered as a "political sounding board" for the Council of Ministers and the Commission. The Economic and Social Committee has even less power and acts only in an advisory capacity. Of the institutions empowered by the Treaty of Rome then, only three are really empowered as Legislative Authorities:

> The Commission - which proposes legislation and monitors compliance in Member States
>
> The Council - which decides whether and in what form proposed legislation will take effect
>
> The Court - which arbitrates prosecutions brought by the Parliament (if legislation is considered unconstitutional) or the Commission (if member states fail to implement legislation)

The original Treaty required environmental Legislation to be proposed according to Articles 100 or 235, both of which required unanimous voting in the Council of Ministers. Such legislation was intended to harmonise trade in the EC where exploitation of environmental resources could favour industry in one Member State over that of another. One significant legislative development in the EC was the amendment of the Treaty on 1 July 1987 by the Single European Act which for the first time establishes environmental objectives and principles for action.

Article 130r (an amendment) states that:

> "1. Action by the Community relating to the environment shall have the following objectives:
>
> (i) to preserve, protect and improve the quality of the environment;
>
> (ii) to contribute towards protecting human health;
>
> (iii) to ensure prudent and rational utilization of natural resources.
>
> 2. Action by the Community relating to the environment shall be based on the principles that preventative action should be taken, that environmental damage should as a priority be rectified at source, and that the polluter should pay. Environmental protection requirements shall be a component of the Community's other policies."
>
> (Single European Act 1987 Article 130r)

Further provisions in the Act enable environmental legislation to be proposed which requires only qualified majority voting (larger states have more votes than smaller states) (ibid Articles 130s and 100a). The Act also prescribes the current legislative procedure outlined in Fig 4.2.

Article 189 of the Treaty of Rome sets out five kinds of "legislation" which may be proposed by the Commission and passed by the Council of Ministers:

Regulations
Directives
Decisions
Recommendations
Opinions

The last two have no binding force and play no role in the empowerment and monitoring of Member States.

A **Decision** is binding upon those to whom it is addressed. Decisions can address procedural matters, matters of definition or can empower the Commission to pursue a course of action not directly related to proposing legislation (such as to represent the EC in international treaty negotiation). Although decisions may lead to refinement of existing legislation or lead to future proposals of regulations or directives, they do not play a significant role in the empowering and monitoring of Member States.

The two most forceful Legislative mechanisms set out in the Treaty are **"Regulations"** and **"Directives"**.

> "A **Regulation** is directly applicable in law in Member States and is mostly used for rather precise purposes such as financial matters and the day to day management of the Common Agricultural Policy. It has so far been used only rarely for environmental matters."
>
> (Haigh 1987 p.2)

Regulations covering environmental matters virtually exclusively address endangered species (whales in particular) and environmentally sensitive areas (forests in particular). More use of regulations at the European level to govern waste production and waste management processes (perhaps in concert with empowerment of a "European Environmental Protection Agency") would mark a shift towards "Federalisation" in the context of environmental policy.

> "A **Directive** is binding as to the results to be achieved, but leaves to the Member States the choice of form and methods. It is therefore the most appropriate instrument for more general purposes particularly where some flexibility is required to accommodate existing national procedures and, for this reason, is the instrument most commonly used for environmental matters."
>
> (Ibid. 1987 p.2)

The Directive has been the key legislative mechanism used for European Environmental Legislation, particularly that which addresses pollution control and waste management.

There are many Directives which address pollution control. The majority address particular issues such as; drinking water, bathing water, sewage sludge, water standards for fresh water fish, shellfish waters, oil pollution at sea and pesticide residues. Such Directives employ standards of all kinds listed in Section 4.1. One Directive however, covering the general case of "Emissions from Industrial Plants" (84/360/EEC) and another covering "Environmental Impact Assessment" (85/337/EEC) address more general issues.

Most Directives addressing waste also address particular issues such as; waste oils, sewage sludge and transfrontier shipment of hazardous wastes. Of key importance for this research however is the "Waste - Framework Directive" (75/442/EEC) which addresses more general issues. More recently, Directives 91/156/EEC and 91/689/EEC have updated legal definitions of "waste" and "hazardous waste" which have led to new registration requirements in the UK, effective from the end of 1994 (ENDS April 1994 p.15-17).

The milieu of Directives issued, and their relevance to industrial and legislative practice in the UK, is well summarised by Nigel Haigh (Haigh 1987). The "Waste - framework Directive" (75/442/EEC), provides a relevant example of the kinds of general requirement stipulated in EC law.

The Directive contains six key elements:

Member states are to appoint "competent authorities" responsible for; planning, organisation, supervision and authorisation of waste disposal operations in their area.

Competent authorities must draw up plans "as soon as possible" including; types and quantities of wastes, requirements for disposal, facilities available and any special arrangements for particular wastes in their area.

Competent authorities are to award permits for; treatment, storage or tipping of wastes on behalf of third parties. The competent authority must periodically inspect operations for which it has awarded permits. First parties disposing of or transporting their own wastes do not require permits but must still be supervised by the competent authority in their area.

According to the "polluter pays principle," the costs of waste disposal and transport are to be borne by waste producers and waste managers.

Member States are to encourage prevention and recycling of wastes and inform the Commission of any rules employed to such effect.

Every three years Member States are to forward "situation reports" to the Commission which in turn forwards reports to the Council and Parliament.
(Haigh 1987 Section 5.1)

The appointment of "competent authorities," some statement relating to the "polluter pays principle" and the preparation of "situation reports" are common elements of environmental Directives. In this case, the Directive stipulates the mechanisms of "permitting" according to planned needs (equivalent to licensing in UK legislative

parlance) and "inspection" to be employed by competent authorities (equivalent to "Regulatory Agencies" in Chapter 3).

Whether to establish new regulatory agencies or assign responsibility to existing agencies, whether to include additional requirements (which do not interfere with free trade within the EC), whether to include administrative costs in the costs borne by waste producers and waste managers and many other legislative options remain at the discretion of Member States.

4.3 Other Developments in The EC

Since 1973, the European Commission has drafted four "Action Programmes on the Environment." Action programmes have no legislative force. They discuss environmental problems and suggest ways in which future legislative proposals may be drafted to address such problems. Action programmes provide a framework for environmental policy in years to come and are not policy statements in themselves.

The Council of Ministers approves the "general approach" of action plans prior to final publication but makes no commitment to points of detail (Haigh 1987 p.11).

Contained in all four action programmes published prior to 1992 are eleven principles for EU environmental legislation. These principles are summarised by Haigh as:

1. The principle of prevention; it is better than cure.

2. Environmental effects should be taken into account at the earliest possible stage in decision making.

3. Exploitation of natural resources which causes significant damage to the ecological balance must be avoided. The natural environment can only absorb pollution to a limited extent. It is an asset which may be used but not abused.

4. Scientific knowledge should be improved to enable action to be taken.

5. The polluter pays principle; the cost of preventing and eliminating nuisances must be borne by the polluter, although some exceptions are allowed.

6. Activities carried out in one Member State should not cause deterioration of the environment in another.

7. The effects of environmental policy in Member States must take account of the interests of the developing countries.

8. The Community and the Member States should act together in international organisations and in promoting international and worldwide environmental policy.

9. The protection of the environment is a matter for everyone. Education is therefore necessary.

10. The principle of the appropriate level. In each category of pollution, it is necessary to establish the level of action (local, regional, national, Community, international) best suited to the type of pollution and to the geographical zone to be protected.

11. National environmental policies must be coordinated within the Community, without hampering progress at the national level. This is to be achieved by the implementation of the action programme and of the "environmental information agreement".

(Haigh 1987 p.10)

The environmental information agreement requires Member States to provide the Commission with information concerning;

national legislation relevant to environmental protection

administrative measures undertaken to implement national legislation

The Commission may decide that legislation would be better applied at Community level. In such circumstances, Member States should suspend their own legislation for five months while the Commission drafts Community legislation. The agreement has no legislative force and is more of a "gentleman's agreement" (Haigh 1987 p.10).

Although international treaties are often negotiated and acted upon by individual states, the European Commission has sought to act on behalf of all Member States in this respect. In order to do so, the Commission must convince other signatory states of its competence as a treaty negotiator and enforcer. Involvement of the Commission does not necessarily preclude Member States from signing treaties or conventions independently but does restrict them to accepting provisions negotiated to apply to the European Community.

4.4 Summary of European Developments

Three key agencies are empowered by The Treaty of Rome;

The Commission
The Council of Ministers
The European Court

The Commission monitors legislative developments in Member States (employing the "environmental information agreement") and develops its own policy framework ("action programmes on the environment") and is empowered to propose legislation based on its findings and legislative principles.

Proposals become legislation after amendment and/or acceptance by the Council of Ministers. Environmental legislation of consequence to Waste Producers and Waste Managers is in the form of Directives.

Environmental Directives require Member States to;

achieve set objectives
empower "competent authorities" (regulatory agencies)
return "situation reports" to the Commission

The Commission monitors compliance on the basis of situation reports and other information acquired through the information agreement. Failure to comply may lead to prosecution in the European Court which can fine Member States or, in extreme cases, suspend Community membership.

European environmental legislation empowers Member States as;

policy makers choosing regulatory tools to be deployed in order to comply with Directives (although some tools may be stipulated).

policy makers choosing regulatory agencies to be empowered as "competent authorities" which will employ regulatory mechanisms to deploy regulatory tools (again some mechanisms may be stipulated in EC Directives)

policy makers establishing their own environmental objectives when the national level is appropriate and when action taken does not interfere with European free trade

The European Commission may also act as a party to international treaties and conventions in place of or as well as Member States. In such circumstances the Commission may propose legislation to execute its responsibility as a treaty signatory.

European environmental legislation enables standards of all kinds to be upgraded at local, regional, national and European levels. At any level, standards may be upgraded once worthwhile and affordable environmental achievements have been demonstrated at lower levels. For example, European environmental legislation is often driven by "successful" legislation in Member States. This dynamic of legislation has been reinforced through the use of phrases like "Best Available Technology Not Entailing Excessive Cost" (note that UK legislation uses the word technique rather than technology).

The Process of drafting legislation is slow, giving rise to time lags. Furthermore, political considerations and the ever present possibility of competitive proposals generate uncertainty as to whether or in what form lower level improvements can influence policy formulation at higher levels.

4.5 Legislative Harmonisation Between the UK and the EC

The historical notion of Britain as "the dirty man of Europe" is now outdated. One example of practice which earned such a reputation is emission of sulphur dioxide which contributed to acid rain in Scandinavia and Germany. Although the Control of Pollution Act placed a duty on the Industrial Air Pollution Inspectorate (IAPI) to ensure the application of Best Practicable Means (BPM) to prevent the escape of "noxious or offensive gases" there was considerable room for interpretation of BPM.

> "As far as air pollution was concerned, "best practicable means" represented a vague concept, never defined in court nor adequately explained by those required to implement it... Strict enforcement of promulgated standards was eschewed by the Industrial Air Pollution Inspectorate, since it invariably preferred the extra-legal powers of negotiation and quiet persuasion. The Inspectorate (and its antecedents), saw itself as being in partnership with industry and only prosecuted the most flagrant and persistent breaches of the law."
>
> (Jordan 1993 p.408)

Although sulphur dioxide may be a noxious and offensive gas, increased chimney height is a simple technical way to prevent local public complaint (a primary concern of the IAPI) which unfortunately did not address grievances of Europeans suffering from acid rain.

The "island mentality" however is not always without justification. The UK historic focus on protecting human health within the confines of the state was also applied to water pollution. Unlike other European States, the UK does not share river water. The Rhine's water is used for drinking and industry in Germany and Holland which has led to the need for agreement over how much any section of it should be polluted by either county. The UK, on the other hand, has justifiably exploited its large estuary capacity as appropriate locations for polluting industries away from upstream sources of water for drinking purposes.

A crucial matter of principle fought for by the UK in the EC has been its right to exploit estuaries (in as much as total pollution discharged to sea is no more than that which would arise from uniformly polluted stretches of river upstream) in the same way as Italian lemon growers exploit the amount of sunlight Italy receives (Haigh 1987 p.20-23). Uniform water emission standards for each stretch of river are not applied in the UK.

The UK's reputation then of fighting for the right to pollute sometimes arises from its particular "island reality" and not always from its "island mentality."

The UK's Best Practicable Means approach seems linguistically identical to the European Best Available Technology Not Entailing Excessive Cost approach. The difference is not linguistic but one of association and precedence. BPM was associated with the UK attitude of protecting environmental targets (predominantly humans) whilst BATNEEC was proposed by the Commission following German achievements employing the *Vorsorgeprinzip*.

Vorsorgeprinzip is often taken to be equivalent to the precautionary principle. This is generally true but it should be noted that the *Vorsorgeprinzip* also includes a notion of prevention not as a means but as an end, to be achieved through step by step reduction of pollutants (RCEP 1988 p.57-58).

This step by step approach is inherent to BATNEEC which enables new emission standards to be issued as and when new techniques are developed. The step by step approach also provides incentive for industry to develop new techniques as a challenge to competitors or as a marketable product. In contrast, BPM provided little incentive for firms to develop new best practicable means, largely due to a lack of confidence that regulators would force competitors to follow suit.

Although BPM may originally have been regarded as equivalent to BATNEEC, differences did not become apparent until legislation based on BATNEEC gradually came into effect.

For example, signs of disparity between the UK and EC approaches were apparent in problems experienced complying with the Toxic Waste Directive (EEC/75/442). UK officials originally claimed that the Directive was based on the UK's Control of Pollution Act and the responsible Minister (Denis Howell) said "There is nothing in the Directive which presents us with any major difficulties of policy" (Haigh 1987 p.140).

During debate in the House of Commons on the Control of Pollution (Special Waste) Regulations (1980) intended to fill gaps in UK legislation, Denis Howell alleged that the regulations still did not fully satisfy the Directive. The reason for this appears to be that the regulations require wastes to be shown as "hazardous to human life or health, whereas the Directive also covers risk to the environment" (Haigh 1987 p.142).

As Directives began to include more and more reference to Euro-wide emission standards based on BATNEEC, the Control of Pollution Act became less and less able to be interpreted as enabling appropriate action for compliance with Directives. Eventually, the UK government published the Environmental Protection Act which incorporated BATNEEC as well as some principles proposed by the RCEP. In the committee stages of the Act the government spokesperson (Mr Trippier) referred to BATNEEC as "more transparent..more explicit" and "a toughening of standards" compared to BPM. This was done without demarking any linguistic difference between the terms and was more of a signal of new precedents which would be established.

> "What was acceptable under BPM would not automatically be accepted as the BATNEEC"
>
> (Jordan 1993 p.417-418).

The input of the RCEP to UK legislative policy was twofold:

The RCEP proposed the idea of setting standards based on the "Best Practicable Environmental Option" (BPEO)." This was to be achieved by considering emissions to all media (air, water and land). This idea was first proposed by the Commission in its Fifth Report (RCEP 1976) and is explained in depth in the Commission's Twelfth Report

(RCEP 1988). BPEO was adopted as an organising principle behind UK implementation of Integrated Pollution Control" (IPC).

The RCEP proposed the idea of a "Duty of Care" for waste in order to "maintain a secure waste stream" in its Eleventh Report (RCEP 1985). This idea was originally based on the idea of applying BPEO standards to waste management and waste production.

These ideas are explored further in Section 4.6. In the context of European Harmonisation however, it is important to note that these ideas are expected to be considered by the European Commission which may then propose a European version of IPC legislation.

4.6 Legislative Developments in the UK

The Environmental Protection Act (1990) is now regarded as the lynchpin of Environmental Legislation in the UK.

> "I think we can now begin to forget the Control of Pollution Act of 1974 and must direct our attention primarily to the Environmental Protection Act of 1990, which as you know, Chris Patten as Secretary of State introduced as being the strictest piece of legislation so far as environmental protection and control was concerned in the whole of the EEC."
>
> (Rossi 1992)

Parts I and II of the Act address pollution control and waste on land. Other parts of the Act are not generally relevant to Waste Producers and Waste Managers in the context of this research.

The Act contributes to harmonising UK and EC environmental legislation by addressing the following "precepts" (factors that contribute to harmonisation).

(1) Enabling empowerment of regulatory agencies as "competent authorities" to satisfy EC Directives

(2) Enabling formal and practical steps to be taken for compliance with standards prescribed in EC Directives

(3) Enabling the compilation of relevant monitoring information by regulatory agencies

(4) Establishing principles more in line with European principles

(5) Establishing principles developed in the UK which are appropriate for local, regional and national regulation. Such principles may eventually contribute to European Environmental Policy Formulation

(6) Empowering regulatory authorities to deploy regulatory tools according to established principles

Precept (1) (enabling empowerment of regulatory agencies as "competent authorities" to satisfy EC Directives) is addressed in Part I Sections 4(2) and 4(3) of the Act. These sections respectively empower the following regulatory agencies:

> "for the purpose of preventing or minimising pollution of the environment due to release of substances into any environmental medium"
>
> (EPA 1990 Part I Section 4(2))

> one chief inspector for England an Wales
>
> one chief inspector and a river purification authority for Scotland.

> "for the purpose of preventing or minimising pollution of the environment due to the release of substances into the air (but not into any other environmental medium"
>
> (EPA 1990 Part I Section 4(3))

> Local Authorities in whose areas a prescribed process is to be carried on or, in the case of mobile plant, where the person operating the process has his principle place of business.

Precept (1) is also addressed in Part II of the Act which defines the roles of Waste Collection Authorities, Waste Disposal Authorities and Waste Regulation Authorities. Waste Collection and Disposal Authorities are responsible for domestic and commercial wastes. Although Waste Collection and Disposal Authorities are major customers of Waste Managers they are not empowered to regulate interactions between Waste Managers and their industrial customers. Waste Regulation Authorities (WRA's) are responsible for granting waste management licences and supervising licensed activities.

> "While a licence is in force it shall be the duty of the waste regulation authority which granted the licence to take the steps needed-
>
> (a) for the purpose of ensuring that the activities authorised by the licence do not cause pollution of the environment or harm to human health or become seriously detrimental to the amenities of the locality affected by the activities; and
>
> (b) for the purpose of ensuring that the conditions of the licence are complied with."
>
> (EPA 1990 Part II Section 42(1))

According to Part II Sections 30(1) and 31(1), Waste Regulation Authorities are:

> County Councils - for non-metropolitan areas in England
>
> Individually constituted bodies - for Greater London, Greater Manchester and Merseyside
>
> District and Island Councils - for other metropolitan areas in England or anywhere in Wales and Scotland

Any two or more of the above established as a single Waste Regulation Authority by the Secretary of State

The Act then, identifies three kinds of "competent authority" empowered to control pollution in three ways (the particular principles applied and tools deployed are outlined below):

The Chief Inspector (Currently assigned to HMIP in England and Wales) - responsible for preventing or minimising pollution of all environmental media

Local Authorities - responsible for preventing or minimising air pollution locally

Waste Regulation Authorities - responsible for preventing pollution and loss of amenity due to locally licensed waste management facilities

Precept (2) (enabling formal and practical steps to be taken for compliance with standards prescribed in EC Directives) is addressed in Part 1 of the Act which relates to the responsibilities of the Chief Inspector and Local Authorities. As mentioned in Section 4.3, European Directives addressing pollution control focuss on particular issues and set appropriate standards, or focuss on general issues and refer to particular standards (of other Directives) and principles for regulation. This enables standards set by new Directives and principles established in more general Directives to be incorporated into UK Regulations.

Part I Section 2 enables the Secretary of State to make the following kinds of prescription:

To describe processes which require authorisation

To describe substances the release of which generally or into particular media requires authorisation

Authorisation may be required after a prescribed date and may be prescribed as falling under central (Chief Inspector) or local (Local Authority) control.

Part I Section 7(2) describes the objectives which regulatory agencies should pursue when determining specific conditions of authorisations.

"Those objectives are-

(a) ensuring that, in carrying on a prescribed process, the best available techniques not entailing excessive cost will be used...

... for preventing the release of substances prescribed for any environmental medium into that medium .....

(b) compliance with any directions by the Secretary of State given for the implementation of any obligations of the United Kingdom under the Community Treaties or international law relating to environmental protection;"

(EPA 1990 Part I Section 7(2))

The Section goes on to list other objectives based on environmental quality standards and plans for future standards (which can be timetabled in authorisations) set out by the Secretary of State.

These objectives enable the Secretary of State to ensure that standards issued in Directives (or those expected to be issued) are accounted for in authorisations granted by the Chief Inspector or Local Authorities. The promotion of BATNEEC is further enhanced in Section 4 of the Act.

> "It shall be the duty of the chief inspector .... to follow developments in technology and techniques for preventing or reducing pollution of the environment due to releases of substances from prescribed processes; and the local enforcing authorities shall follow such of those developments as concern releases of substances from prescribed processes designated for local control"

(EPA 1990 Part I Section 4(9))

The Act then, has enabled new standards to be introduced or timetabled as and when Directives take effect or are proposed (and likely to take effect) and according to plans made by the Secretary of State. The Act also devolves some responsibility to the Chief Inspector and Local Authorities to develop their own knowledge of technologies and techniques and set standards accordingly (according to the BATNEEC principle). These provisions enable regulations to be imposed to comply with standards set by European Directives. Use of "authorisations" based on Plans made by (or authorised by) the Secretary of State satisfies the "permitting" based on plans approach common in framework type Directives. One other compliance requirement, preparation of "situation reports" is addressed below with Precept (3).

Precept (2) is also addressed in Part II of the Act. As mentioned in section 4.3, the European Waste Framework Directive requires that permitting be employed, based on plans drawn up by "competent authorities."

Part II Section 50(1) of the act places a duty on Waste Regulation Authorities

"(a) to carry out an investigation with a view to deciding what arrangements are needed for the purpose of treating or disposing of controlled waste which is situated in its area ....

(b) to decide what arrangements are in the opinion of the authority needed for that purpose and how it should discharge its functions in relation to licences.

(c) to prepare a statement ("the plan") of the arrangements made and proposed to be made..."

(EPA 1990 Part II Section 50(1))

This section goes on to stipulate the kinds of information to be included in plans which fully satisfies the required and suggested considerations stipulated in the Waste Framework Directive (75/442/EEC). Waste Regulation Authorities are also empowered by the Act to supervise licensed activities and require licence holders to comply with conditions laid out in the licence or face suspension or revocation of the licence.

Although the Act promotes and makes provision for preparation of recycling plans for domestic wastes, no formal prescription is offered to cover recycling of industrial wastes.

The Act then, contains both specific reference to regulations being driven by EU Legislation and includes particular elements drawn from relevant Directives. One formal element of compliance is the preparation of situation reports which will be addressed alongside Precept (3).

Precept (3) (enabling the compilation of relevant monitoring information by regulatory agencies) is addressed in Part I Section 19 of the Act. This section empowers the Secretary of State to require any enforcing authority to furnish him with any information related to its duties that he may require. In turn, the enforcing authorities can demand any information that it requires in pursuit of its duties from any person. This section specifically states that reasonable requests for information includes information which the UK is obliged to provide under Community Treaties.

Precept (3) is also addressed in Part II of the Act. Information about waste management is largely covered by plans made by Waste Regulation Authorities and submitted to the Secretary of State (discussed above). The Waste Framework Directive requires that this information be returned to the Commission "as soon as possible." This is addressed in Part II Section 50(11) of the Act which states that:

> "The Secretary of State may give to any waste regulation authority directions as to the time by which the authority is to perform any duty imposed by this section specified in the direction; and it shall be the duty of the authority to comply with the direction."
>
> (EPA 1990 Part II Section 50(11))

The Act then enables the Secretary of State to demand information from regulatory agencies with which to prepare situation reports required by European Directives.

Precept (4) (establishing principles more in line with European principles) is addressed in many sections of the Act. For example the phrase "best available technique not entailing excessive cost" is used to describe principles by which the Secretary of State should prepare plans and by which regulatory agencies should enforce regulations. For plans made by the Secretary of State the *Vorsorgeprinzip* is applied:

> "The Secretary of State may make plans for-....
>
> (c) establishing limits of the descriptions specified in section (2)(a) above [prescribed substances] so as progressively to reduce pollution of the environment;"

(d) the progressive improvement in the quality objectives and quality standards established by regulations..."

(EPA 1990 Part I Section 3(5))

Throughout the Act (and in quotes given above), reference is frequently made to protection of the environment in addition to protection of human health. Indeed the Act stipulates the following definition:

"Pollution of the environment" means pollution of the environment due to the release (into any environmental medium) from any process of substances which are capable of causing harm to man or any other living organisms supported by the environment."

(EPA 1990 Part I Section 1(3))

This definition of pollution is broader than the "noxious or offensive" and the "hazardous to human health" previously employed in the UK. The principle of considering all environmental media is in line with European ideas of reducing pollution rather than shifting the point of pollution.

The Act also makes provisions for regulatory agencies to recover their administrative and inspection costs by charging a licence fee. The Act also empowers regulators to conduct remedial action where pollution has occurred and recover any costs from persons found to be responsible. This is in line with the polluter pays principle.

With respect to **Precept (5)** (establishing principles developed in the UK which are appropriate for local, regional and national regulation. Such principles may eventually contribute to European Environmental Policy Formulation), two key principles developed in the UK are;

Best Practicable Environmental Option (BPEO)

Duty of Care as respects waste

BPEO is referred to in Part I Section 7(7) of the Act which states that:

"The objectives referred to in subsection (2) [Section 7(2) referred to with Precept (2) above] above shall, where the process-

(a) is one designated for central control; and

(b) is likely to involve the release of substances into more than one medium;

include the objective of ensuring that the best available techniques not entailing excessive cost will be used for minimising the pollution which may be caused to the environment taken as a whole by the releases having regard to the best practicable environmental option available as respects the substances which may be released."

(EPA 1990 Part I Section 7(7))

BPEO was originally proposed by the RCEP in its Fifth Report (RCEP 1976) and is explained in detail in its Twelfth Report (RCEP 1988). Although the RCEP

recommended application of the BPEO principle to waste disposal in its Eleventh Report (RCEP 1985 p.41-43) this recommendation was not adopted in the Act.

BPEO is the organising principle employed for Integrated Pollution Control (IPC) in the UK. IPC itself is not unique to the UK. In 1988 a "Symposium" on "Integrated Pollution Control" held in Brussels defined IPC as:

> "the range of organisational and legislative provisions that enables institutions to deal with the connected nature of environmental problems."
> (Bennet 1992 p.81)

In 1991 the Council of the Organisation for Economic Cooperation and Development recommended its Member Countries to practice Integrated Pollution Prevention and Control for three reasons:

> "considering that substances can move among environmental media (air, water, soil and biota) as they travel along a pathway from source to a receptor and can accumulate in the environment;
>
> considering that controls over releases of a substance to an environmental medium can result in shifting the substance to another environmental medium;
>
> considering that in many Member countries, pollution control efforts focus on each environmental medium separately and that controls over the marketing and use of substances are carried out as separate activities."
> (Haigh 1992 p.84)

The BPEO principle addresses the considerations of IPC. While BATNEEC is applicable to single environmental media, BPEO can be applied to possible permutations of BATNEEC controls over each and every medium. BPEO is very similar to BATNEEC in that it can be applied progressively accounting for advances in technologies and techniques. As BATNEEC is to various pollution control techniques for a particular kind of emission, so BPEO is to various BATNEEC's applicable to a particular kind of process.

The "Duty of Care etc. as respects waste" is set out in Part II Section 34 of the Act and is defined in Subsection (1):

> "Subject to subsection (2) below [not applicable to household waste at source], it shall be the duty of any person who imports, produces, carries, keeps, treats or disposes of controlled waste or, as a broker, has control of such waste, to take all such measures applicable to him in that capacity as are reasonable in the circumstances-
>
> (a) to prevent any contravention by any other person of section 33 above; [prohibition of unauthorised or harmful depositing, treatment or disposal of waste]
>
> (b) to prevent the escape of the waste from his control or that of any other person; and
>
> (c) on the transfer of waste, to secure-

(i) that the transfer is only to an authorised person or to a person for authorised transport purposes; and

(ii) that there is transferred such a written description of the waste as will enable other persons to avoid a contravention of that section and to comply with the duty under this subsection as respects the escape of waste."
(EPA Part II Section 34(1))

The Duty of Care was recommended in the RCEP's Eleventh Report (RCEP 1985 p.38). The objective of this (and other recommendations was stated as;

> "to ensure the *long-term integrity and security of the waste stream* - a term which we use to mean the life history of an item of waste from the point at which it originates to the point at which it ceases to be a waste or is finally disposed of."
>
> (RCEP 1985 p.37)

Other factors which the RCEP recommended as contributory to this objective include;

Minimising and giving value to waste;

> "In most commercial transactions, successful suppliers take care to ensure that their products reach customers safely, expeditiously and up to specification. The dissatisfied customer can seek to redress or at least take his custom elsewhere. But when the product is waste this normal commercial pressure does not operate. The consignee in this situation is the environment, and must be protected against the careless and uncaring by regulation and control. The aim must be to ensure that disposal costs are not externalised but remain coupled to the original processes, operations and transactions which lead to waste generation."
>
> (RCEP 1985 p.40)

The Act does not directly enable measures that "give value to wastes." However, provisions which promote secure waste streams and set suitable standards (below) should make the costs of appropriate waste management less avoidable by waste producers.

Maintaining a secure waste stream;

> "enforcement of best practice for storage transport and disposal and retention of documentation concerning wastes for a specified period"
>
> (Ibid p.40)

The Act addresses this issue by empowering Waste Regulation Authorities to award licences and supervise licensed sites and transport operations in the interest of protecting the environment and local amenity.

Setting suitable standards

> "ensuring that waste producers consign wastes to secure waste streams"
>
> (Ibid p.40-41)

The Act addresses this issue by placing a duty on waste producers to consign wastes only to persons appropriately authorised.

Ensuring disposal by BPEO

> "Extending the BPEO principle to wastes, considering environmental effects of wastes at source, in transport, during treatment and after disposal or recycling. Appropriate options should be applied to particular kinds of waste. For example, **Anything which goes to landfill** should be degradable or be in a stable or solid state."
>
> (Ibid p.41-42)

This recommendation has not been pursued in the Act.

The Act then, includes two principles developed in the UK largely by the RCEP. The BPEO principle in particular is considered as contributory to European efforts to implement IPC (RCEP 1988 p.4).

Precept (6) (empowering regulatory authorities to deploy regulatory tools according to established principles) is addressed by the Act which specifies particular kinds of regulations to be enforced by different regulatory agencies using particular tools.

Part 1 Sections 3(2) and 3(4) prescribe the kinds of standards which may be applied to prescribed processes or substances. These standards are:

> Emission standards relating to any substance released form prescribed processes (Subsection 2a).
>
> Monitoring standards for measurement and analysis of emission regulated by emission standards as above (Subsection 2b)
>
> Process standards covering any aspect of prescribed processes (Subsection 2c)
>
> Environmental quality standards for any medium nationally or locally relating to any substances released into that medium from any process. (Subsection 4)
>
> (EPA 1990 Part I Section 3)

The following regulatory mechanisms and principles are also stipulated:

(i) Standards are to be enforced by regulatory agencies awarding licences specifying such standards as are applicable to the process so authorised. In every authorisation there is a general condition that:

> Local Authorities ensure that emissions to air are limited according to BATNEEC (Section 7(4))

> The Chief Inspector ensures that emission to all media are limited according to BPEO (Section 7(7)).

(ii) Regulatory agencies are empowered to inspect licensed activities (Section 17).

(iii) Regulatory agencies are empowered to levy a charge on application for a licence to cover administrative and inspection costs (Section 8).

(iv) Regulatory agencies may revoke licences (Section 12) or serve enforcement or prohibition notices on persons operating licensed processes (Sections 13 and 14). Failure to comply with such notices can lead to prosecution conviction and/or a fine and any costs incurred to remedy environmental damage caused.

Part II of the Act similarly empowers Waste Regulation Authorities to award licences and inspect licensed facilities and make a charge to cover administrative and inspection costs.

(v) Conditions of waste management licences are also dependent on the authority being convinced that the applicant is a "fit and proper person" for the purposes of preventing:

> pollution of the environment
> harm to human health
> serious detriment to the amenities of the locality
>
> (EPA 1990 Part II Section 36(3))

Licences may include conditions appropriate to:

> the activities which the licence authorises
> the precautions to be taken and works carried out in connection with or in consequence of those activities
>
> (EPA 1990 Part II Section 35(3))

Licences may be suspended or revoked if it appears to the authority that these conditions are no longer met as for (iv) above.

If environmental damage occurs due to waste management activity WRA's may take remedial action and recover costs incurred from the current owner of the as for (iv) above.

(vi) Any person who deposits, keeps, treats or disposes of waste without a valid license in contravention of licence conditions may be prosecuted which may result in conviction and/or a fine.

(vii) Although Parts I and II of the Act do not directly address other areas of environmental concern, the regulatory authorities are given a duty to consult with other regulatory agencies when regulating processes which may influence areas which concern other authorities. Licences may then include conditions recommended by those authorities. These authorities include:

> The Health and Safety Executive
> The National Rivers Authority
> The Nature Conservancy Council

4.7 Implementation; the example of HMIP

In 1989-1990 HMIP faced the task of preparing 200 BATNEEC guidance notes and ensuring compliance in addition to ongoing policing of regulation ranging from Health and Safety at Work to Control of Radiation. One key indicator of governmental determination to make new legislation effective was the provision of resources for HMIP.

From April 1988 to April 1989, a recruitment drive coupled with pay increases led to an increase of professional staff (mainly inspectors) from a complement of 122 to 135 and remained around that level (HMIP 1990). One report put the requirement for realistic enforcement at a complement of 400 (ENDS, November 1990).

Pressures for higher staffing levels arose out of new tasks required of HMIP (issuing new licences and guidance notes) and increased complexity of new inspection practices (especially when considering BPEO standards covering all environmental media). These pressures though were mitigated by new responsibilities for firms to monitor their own emissions.

> "An increasing amount of monitoring is being carried out by industry requiring fewer routine visits by inspectors and the sampling teams who can concentrate their efforts on checking monitoring data.
>
> Formal inspections are carried out in greater detail involving scrutiny of plant and operating procedures. Consequently each inspection takes longer."
>
> (HMIP 1990 p.29-30)

Although BATNEEC and BPEO are suggestive of dynamic legislation enabling a free hand for technological innovators, this is offset by prescription of technology in guidance notes. The significance of this issue is dependent largely on the flexibility of HMIP's attitudes.

> "The traditional approach to much pollution regulation in Britain has been one of informal working together between operators and enforcing authorities. This is a legitimate approach, and one which has been effective in achieving high standards. However the EP Act marks a shift to a more structured approach to regulation. In line with this trend and to make the most effective use of available resources, HMIP's relationship with the individual operators whom it is charged with regulating must become more structured."
>
> (HMIP 1990 p.6)

To what extent this statement will remain a reference to historically low rates of prosecution by HMIP or will be seen to have heralded a transition to an inflexible institution (perhaps motivated by a need to be seen as effective) remains to be seen.

From HMIP's fourth annual report, it seems that some of the issues raised above are being resolved. Further pay increases and recruitment have raised staffing to 232 in

April 1991 and to 451 by the end of 1993. Further evidence of good resourcing is evident in the fact that HMIP inspectors are now issued with portable personal computers linked into HMIP data bases via modem and a voice activated fax response enquiry system is used at HMIP's central office (HMIP 1991 and 1992, ENDS 1994).

Prosecutions have increased dramatically and inspectors have been assigned to liaise with industry sectors. This demonstrates recognition of the issue of how to prosecute efficiently and fairly without being inflexible to the needs of industry.

4.8 Other Developments in the UK

The UK Government declared in its White Paper "Our Common Inheritance" (1990), that it intends to pursue a "market based approach to the polluter pays principle." The White Paper has no legislative force but is a statement of intent.

In the context of Waste Policy, this market based approach is suggested in "The Government's response to the Eleventh Report of the Royal Commission on Environmental Pollution." On the issue of whether and to what extent industry should adopt "low- or non-waste technology" the response states that:

> "The Government believe that the market place should allocate the resources between different methods and materials within safe environmental limits laid down by the Government."
>
> (Department of the Environment 1986 p.6)

With particular reference to recycling the response states that:

> "The economics of the reclamation industry often involve a fine balance between availability of waste materials, costs of sorting and treating, markets for recycled products and the prices of the raw material. Intervention by Government can alter this balance to no-one's advantage. Nevertheless, the Government acknowledge that there is some lack of awareness in industry and commerce of the opportunities which do exist for recycling. They hope that, by increasing this awareness, industry will be stimulated into making the most of its waste products in its own best interests"
>
> (Ibid p.3)

The free market approach to the polluter pays principle precludes intervention to favour any particular kind of environmental option (over and above those that enable regulatory limits to be satisfied), but it does enable intervention to ensure that industrial policy formulation is well informed as regards options available. Dissemination of information is also encouraged as follows:

> Process guidance notes are issued by HMIP (these contain technical information)
>
> Subsidy covers half the costs of consultancy incurred by firms considering changes to satisfy new regulatory standards

> Information about regulatory and technical issues has been compiled by Warren Spring Laboratory (which has now closed down) on behalf of the DTI. A telephone hotline was used to disseminate this information predominantly to consultants (CEST 1991).

The free market approach precludes subsidy of any option type as a matter of principle.

Another development in the UK is the ongoing publication of Waste Management Papers which provide guidance to WRA's. The following principles are laid out in these Papers:

> Prospective landfill operators should submit plans to WRA's which anticipate environmental and health problems and demonstrate precautions to be integrated into the design and working plan for the site. Particular precautions include:
>
> > Collection and monitoring of methane and leachate
> >
> > Engineering standards for site construction and closure to ensure containment of wastes.

The phrase "fit and proper persons" to hold a waste management licence is further explained. Three criteria are employed:

> Legal - the person should not have been previously convicted of offences relevant to waste management
>
> Technical - the person or an employee thereof should have technical competence and qualifications appropriate to the activity to be licensed
>
> Financial - the person should demonstrate they have sufficient finance to fulfil provisions appropriate to the activity to be licensed, such as site closure and aftercare for landfill sites.

The charges to be made by WRA's for licences are specified in a charging scheme. The scheme includes lower charges for recycling activities. The cost to landfill operators and recyclers can be analysed. For an activity receiving 100,000 tonnes of waste per year the fixed costs (payable in the first year) and annual costs to operators are approximately as shown in Table 4.1. These costs are very small compared with prices charged per tonne of waste at landfills (£10-20 per tonne). The differences in charges are more likely to reflect lower administrative and inspection costs for recycling facilities rather than a serious attempt at market intervention.

Table 4.1: Costs due to Charges made for Waste Management Licences Appreciated by Landfill Operators and Recyclers

	Landfill	Recycling
Fixed cost per tonne throughput	3p	1p
Annual cost per tonne throughput	3p	1p

4.9 Summary of UK Developments

The findings of research presented in this chapter can be considered in terms of the seven "Legislative" research questions posed in Section 3.2.

L1: What are the stated goals and objectives of environmental legislation in the UK to which recycling could contribute?

Legislative waste policy formulation in the UK can be considered as founded on the following five principles all of which are laid down in the "Single European Act" (1987);

(1) Limiting pollution at source

(2) Maintaining local, regional and national environmental quality standards

(3) Containment of wastes in disposal facilities

(4) Maintaining secure waste streams
(5) A market based approach to the polluter pays principle

These principles arise partly from requirements imposed by European Legislation which in turn is empowered by the EC Members States (including the UK).

The requirements also arise partly from unilateral legislative initiatives taken by the UK Government.

Note that UK Government policy focuses on environmental conservation with little consideration given to resource use issues.

L2 and L4: What benefits of recycling industrial wastes and other options are recognised by legislators as contributory to the achievement of legislative goals and objectives?

The UK government does not recognise benefits of any particular option for use in industry, but rather recognises problems associated with industrial activity. Whether recycling or other options can contribute to resolving such problems is an issue which the UK Government has left for industrialists and the market to resolve within the confines of standards imposed to address problems associated with industrial activity.

L3 and L5: What legislative mechanisms are intended to encourage recycling of industrial waste or other options in the UK?

(1) Limiting pollution at source is primarily the responsibility of Local Authorities (air pollution only) and HMIP (which may consult with other regulatory agencies such as the National Rivers Authority if discharge to water is involved) and employs the regulatory tool of emission standards.

Emission standards are enforced by employment of regulatory mechanisms including;

licences awarded or revoked

inspection of industrial plant

prosecution

Legislation makes unlicensed release of controlled substances a criminal offence.

Emission standards to single media are set according to the BATNEEC principle and they may be upgraded as and when new techniques are shown to reduce emissions (in the UK or the EC) or according to step by step plans for timetabled improvements.

Emission standards into multiple media are set according to the BPEO principle which considers the best known permutation of BATNEEC's for the processes, substances and media concerned.

The employment of the BATNEEC principle and step by step plans enables compliance with emission standards (also based on BATNEEC) stipulated in European Directives.

(2) Maintaining local, regional and national environmental quality standards (environmental quality standards are a regulatory tool) is the responsibility of Local Authorities WRA's and HMIP as well as The National Rivers Authority and Nature Conservancy Councils (whose roles are not explored in this research).

Environmental quality standards are maintained by employing the following regulatory mechanisms;

limiting the number of polluting processes (of a given type) licensed to operate locally, regionally or nationally

remedial action taken by regulatory agencies (which may be charged to polluters if they are identified)

Environmental quality standards may be improved by step by step planning enabling compliance with quality standards stipulated in European Directives.

(3) Containment of wastes in disposal facilities is the responsibility of WRA's.

Containment involves ensuring that process standards for site construction and operation are adherred to. For example, the working face of the site should be covered with inert material to a six inch depth every three feet (and at the end of a day). Process standards are enforced by employing the following regulatory mechanisms:

licences are awarded or revoked
inspection of waste facilities
prosecution

Legislation makes unlicensed holding, keeping, treating or disposing of wastes a criminal offence.

Licences are awarded to "fit and proper persons" who can demonstrate plans for waste management activities which incorporate suitable process standards (including site design and aftercare) which prevent;

pollution of the environment

harm to human health

serious detriment to human health

Such plans must be in line with plans drawn up by WRA's for managing waste in their region. WRA's have a duty to consult other regulatory agencies prior to issuing licences.

(4) Maintaining secure waste streams is the responsibility of anyone importing, producing, carrying, keeping, treating, brokering or disposing of waste (except householders as respects domestic waste).

Any person passing waste on to another person is obliged by the duty of care to ensure that a written description enabling appropriate waste management accompanies the waste and to ensure that the waste receiver holds an appropriate licence. Self regulation is encouraged because to do otherwise, or to dispose of waste without a licence or to allow waste to escape from one's control is a criminal offence.

(5) A market based approach to the polluter pays principle is the responsibility of the UK Government which endorsed it and all regulatory agencies it has empowered to regulate pollution.

Essentially it means that where anyone is identified as having contravened environmental laws they should pay. It also means that changes required by law should be paid for by polluters. Governmental assistance is only provided for

dissemination of information or generation of new information (through research or development of innovative techniques).

This principle is promoted by use of the following market mechanisms:

> Charges for licences to cover administrative and inspection costs of regulatory agencies
>
> Monitoring standards stipulated in licences. Firms must pay to monitor their own emissions
>
> Powers for regulatory agencies to recover costs of remedial action taken as a consequence of pollution
>
> Powers for courts to impose fines and/or prison sentences if regulatory agencies successfully prosecute unlicensed polluters
>
> Subsidies offered for consultancy targeted at implementing change in response to regulatory changes
>
> Subsidies for environmental technology are limited to innovative developments and given no more weight than other technological innovations (firms must apply to schemes like the DTI SMART award scheme)

The market based approach to the polluter pays principle is a stricter interpretation than that imposed in the EC generally. The EC interpretation of this principle refers to polluters paying for environmental damage caused but not to polluters which intend to obey regulations bearing all the costs of adopting improvements.

L6: What are the differences between recycling and other options with respect to:

> **(a) achievement of the stated goals and objectives of environmental legislation in the UK?**
>
> **(b) legislative mechanisms intended to encourage each kind of response in the UK?**

From the research conducted, there are few apparent differences between recycling and other options from the perspective of legislators in the UK. Regulatory mechanisms employed are targeted at achievement of legislative objectives with minimal interpretation as to how objectives should be achieved by industrialists.

One key difference is that waste management operations are regulated to ensure "complete containment" of pollutants whilst other industrial operations are regulated to limit escape of pollutants. Given that no form of waste management enables "complete containment" the "containment" objective seems to based on a false assumption.

For recycling options which are not considered as forms of waste management by regulators limited pollution is allowable. However, before April 1994, no account

was taken of pollution due to wastes arising in BPEO assessments. Options which prevented wastes being sent to waste management facilities did not receive credit for preventing pollution in waste management operations. In April 1994, HMIP updated pollution indices used for BPEO assesements to represent some pollution associated with wastes.

L7: Under what circumstances do differences between recycling and other options matter for the satisfaction of legislative goals and objectives and for responses encouraged by legislative mechanisms used?

Given that few differences have been identified the question seems irrelevant. However, considering the broader context of the research activity, it may matter that choice of response to legislative mechanisms is delegated to industrialists.

Circumstances which determine if the UK government's strategy works as well in practice as it appears to in theory are the circumstances of industrial agencies. Whether industrial agencies are limited in the responses which they can adopt in a way which governments would not be is the subject of the following chapters.

The difference identified regarding a lack of recognition of waste facilities as pollution sources matters in as much as waste facilities are polluting.

4.10 Conclusions

The research presented in this chapter was founded on the assumption that important aspects of Legislative Policy could be determined by investigating a hierarchy of Legislative Agencies which empower and monitor subsidiary agencies. In this case, a hierarchy is hard to identify since the EC both empowers and is empowered by the UK Government (and governments of other Member States). However, the process of investigating empowerment and monitoring arrangements does successfully identify detail appropriate for incorporation in the conceptual model of Waste Policy formulation and implementation. This detail is summarised in Section 4.9 and is used in Chapter Six to further develop the conceptual model.

The important findings presented in this chapter and summarised in Section 4.9 are of four kinds;

Objectives of Legislative Agencies in the UK are identified.

Sets of regulatory tools deployed and regulatory mechanisms employed by regulatory agencies are identified. Different sets of tools and mechanisms are associated with different legislative objectives.

Relative benefits (or disbenefits) of different waste options are not recognised by Legislative Agencies. However, general principles employed by Legislative Agencies, intended to promote environmental improvements in industry whilst leaving the choice of method for improvement to Industrial Agencies are identified.

Legislative Waste Policy in the UK does not distinguish different waste options at the level of employing regulatory mechanisms to regulate Waste Producers. However different regulatory mechanisms employed to regulate Waste Managers are identified.

Some differences between waste options may matter depending on the process by which changes to Waste Manager practices affect Waste Producers and vice versa. This aspect of Waste Policy formulation is explored in subsequent research presented in Chapters Seven to Nine.

Differences between waste options appreciated by Waste Producers are not subject to regulatory intervention (except due to indirect affects of standards imposed on Waste Managers). The consequences of the "market based approach" endorsed by the UK Government in terms of adoption of waste options by Industrial Agencies according to their own policy agendas are explored in Chapter Five. Whether the objectives of Waste Producers and the conditions arising from regulatory mechanisms employed are congruent with the objectives of Legislative Agencies is explored in Chapter Six where research findings presented in this chapter and in Chapter Five are compared.

CHAPTER FIVE

The Role of Waste Producers in the Process of Waste Policy Formulation and Implementation

5.1 Introduction

From preliminary research presented in Chapter Four it is apparent that Waste Producers have an important role in the process of Waste Policy formulation and implementation. This role is significant because recent changes to environmental regulation emphasise choice of waste options by Waste Producers.

Implementation of waste options can be judged alongside the goals and objectives of Waste Producers and the consequences for Waste Producers of regulatory mechanisms employed by Legislative Agencies. In this way, not only are particular waste options identified as implemented under different conditions, but a rationale is also be identified for Waste Producers to improve understanding of their role in Waste Policy formulation and implementation.

Research into the conditions, attributes and objectives of Waste Producers relevant to Waste Policy formulation was conducted employing the particular technique of interviewing environmental consultants.

Environmental consultants mobilise information about:

Current and likely future regulations pertinent to an industrial client

Technical options which contribute to satisfying pertinent regulations

Mobilisation of this information is encouraged by subsidies available to cover half the cost of consultancy incurred by firms responding to recent regulatory changes.

It was expected that environmental consultants would be knowledgeable about other (non-legislative) pressures on their clients to adopt environmental improvements. Such information is useful for modelling industrially sourced elements of Waste Policy formulation.

In terms of the conceptual model presented in Section 3.2 the key process investigated by the interviews is the feedback loop between;

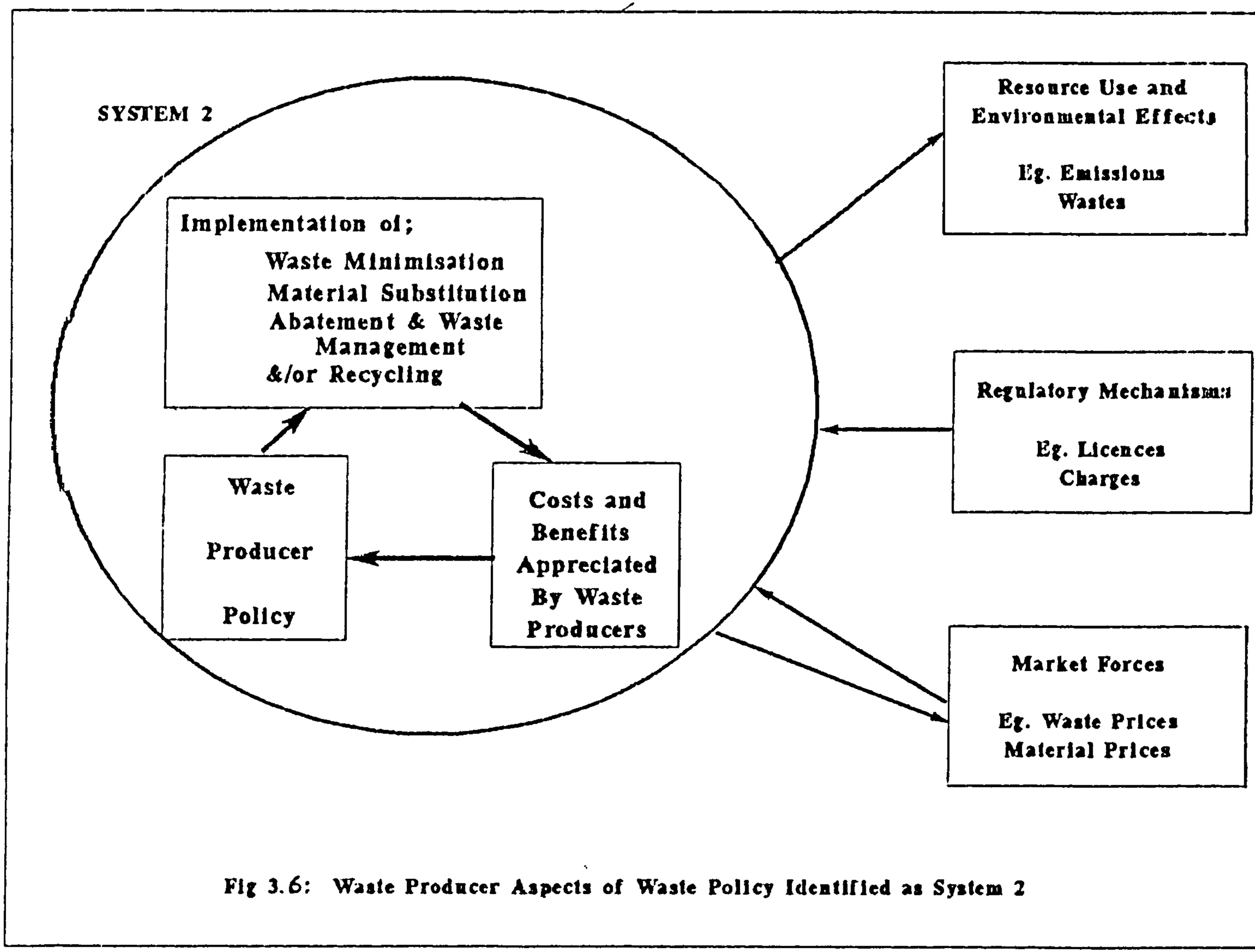


Fig 3.6: Waste Producer Aspects of Waste Policy Identified as System 2

Waste Producer policy

Implementation of;

Waste Minimisation
Material Substitution
Abatement and Waste Management
and/or Recycling

Costs and Benefits for Waste Producers

This feedback loop is identified as "System 2" in Section 3.3 and is represented in Fig 3.6, shown on p.88 for easy reference.

The objectives of this research are:

To identify regulatory mechanisms and market forces which influence selection of waste options by Waste Producers such as market based mechanisms that affect appreciation of costs and benefits by Waste Producers

To identify rationales by which Waste Producers formulate Waste Policy to contribute to the assumed goal of maximising profit

To identify conditions which influence implementation of waste options by Waste Producers such as the kinds of problems which firms face implementing options and the resources available to overcome such problems

5.2 Interview Method

Contacts were initially established at the "Environmental Technology Exhibition" held at Birmingham NEC in October 1991 and at a conference called "European Community Environmental Legislation" organised by IBC Ltd (10 July 1991). Further contacts were generated from recommendations of respondents. Interviews were conducted until July 1992.

Interviews were conducted either;

At the exhibition or conference where contact was established

By telephone at a later date

At meetings arranged by telephone at the respondent's place of work

Prior to telephone contact, respondents were sent a standard fax which;

Outlined the information being sought

Offered an opportunity for respondents to find out about the cross campus "Environmental Programme" being established at Cranfield University at that time

- At the time, information sought was expressed in the fax as:

"To gain some understanding of how industry may assess response options **(waste minimisation, materials substitution, improved waste management and/or recycling)** to legislation in terms of;

The kinds of technical constraint associated with each option (as above).

Relationships between an operation where change is to be considered and an organisation's strategic considerations.

The risks of non-compliance regarding strictness of legislation and degree of enforcement."

These issues seemed appropriate to focus consultants attention on the concerns of Waste Producers in the context of Waste Policy formulation and implementation.

Particular respondents were selected for interview according to the following two criteria:

(i) They were available to talk to at the conference or exhibition where contact was established unless;

Reason A - the firm the respondent worked for did not at first appear to be primarily concerned with selling its own or an associate firm's products

Reason B - the firm the respondent worked for was not concerned with only one of the issues outlined above (some firms provided legal advice only).

(ii) If the respondent was recommended by someone already interviewed as a person familiar with issues addressed in the interview, then an attempt was made to interview them (even if criteria set (i) did not apply).

The interviews were conducted informally, as conversations, guided towards addressing the issues outlined above. It was explained that the interviews were for research purposes rather than with a view to purchasing goods or services. The interviews commenced with a summary of information sought (as given in the fax) and were conducted to cover each of the four topics (in the order given in the fax). Respondents also provided information about how they do their jobs and on other matters (often about how and when environmental improvement would become noticeable in UK industry). Rough notes were taken during interviews and written up afterwards. Quotes were only recorded rarely.

The notes from each interview are paraphrased under the following headings an Section 5.3:

Category A: The kinds of technical constraint associated with each option type

Category B: Relationships between an operation where change is to be considered and an organisation's strategic consideration

Category C: The risks of non-compliance regarding strictness of legislation and degree of enforcement

Category D: How respondent performs the job of consultancy

Category E: Other information offered

A priori selection of categories of information helped to remove bias from interpretation of the research findings. However, the information categories A to E are not mutually exclusive. Respondents gave information in one category which other respondents placed in other categories. This may have been due to respondents addressing issues from say Category B before the appropriate issue was introduced in the conversation or may have been due to confusion between "strategic concerns of the respondent's clients" and "technical constraints associated with different options."

In Section 5.3, each of the information categories is correlated with elements of System 1 as represented in Fig 3.3.2 to enable analysis of responses in terms of the Waste Producer questions derived in Section 3.3.

5.3 Results

Table 5.3 summarises the following information about respondents;

Job Description

Place of initial contact (or reference to another respondent who recommended contact)

Whether a standard fax was sent prior to attempts made to arrange an interview.

The duration of any interview (in minutes) and whether it was by telephone (T) or at a meeting

Notes-

If the interview was at the conference or exhibition where contact was initially established (any other meetings were conducted at the respondent's place of work)

If the respondent suggested other respondents with useful knowledge

Table 5.1: Respondent Descriptions and Forms of Contact

Respondent No.	Job Description	Initial Contact	Fax Sent	Interview Dur'n/ Minutes	Notes
1	Waste Analyst	ET	No	40 (M)	Interview at ET
2a	Principal Consultant	ET	Yes	25 (T)	Suggested 2a & 2c
2b	Legal Adviser	Via 2a	No	15 (T)	
2c	Technical Adviser	Via 2a	No	30 (T)	Suggested 20
3	Marketing	ET	Yes	Failed	Suggested 20
4a	Dept. Manager (Air Quality)	ET	No	20 (M)	Interview at ET Suggested 4b & 4c
4b	Dept. Manager Environmental Strategy	Via 4a	Yes	120 (M)	4b & 4c were met together
4c	Technical Adviser (Waste Control)	Via 4a	Yes	120 (M)	
5	Consultant	ET	Yes	Failed	
6	Consultant	ET	Yes	Failed	
7	Division Manager (Environmental)	ET	Yes	Failed	
8	Principal Consultant	ET	Yes	Failed	
9	Environmental Safety Consultant	ET	Yes	10 (T)	Suggested 17
10	Business Development	ET	No	30 (M)	Interview at ET
11	Sales	ET	No		Reason A (p.90)
12	Principal Consultant	ET	No	20 (M)	Interview at ET

Table 5.1 Continued

Respondent No.	Job Description	Initial Contact	Fax Sent	Interview Dur'n/ Minutes	Notes
13	Sales	ET	No		Reason A (p.90)
14	Business Development	ET	No	15 (M)	Interview at ET
15	Sales	ET	No		Reason A (p.90)
16	Sales Manager	ET	No	10 (M)	Interview at ET
17	Legal Consultant	ET & Via 9	No	15 (T)	Criteria (ii) (p.90)
18	Legal Consultant	ET	No		Reason B (p.90)
19	Research Director	ET	No	10 (M)	Interview at ET
20	Technical Adviser	Via 2c	No	45 (T)	Suggested 21
21	Manager	Via 20	No	60 (M)	
22	Consultant and General Counsel	IBC	No	40 (M)	Interview at IBC
23	Consultant (Waste Auditing)	IBC	No	20 (T)	Suggested 24
24	Technical Adviser (Liquid Wastes)	Via 23	No	15 (T)	

KEY to Table 5.1:

ET - The "Environmental Technology Exhibition held at Birmingham NEC (8-10 October 1991)

IBC - The IBC conference on "European Community Environmental Legislation (10 July 1991)

(T) - Interviewed by telephone

(M) - Interviewed by meeting

Failed - At least three follow up telephone calls failed to enable an interview.

If interviews were not arranged for one of the reasons given in Section 5.2, Criteria (i).

Of respondents initially contacted at the Environmental Technology Exhibition and selected for further contact (those to whom faxes were sent, excluding 4b and 4c), two out of seven were successfully interviewed. Of respondents contacted upon the recommendation of those already interviewed, eight out of eight were successfully interviewed (this high response rate seemed to be facilitated by "name dropping").

In total nineteen respondents from fifteen different firms were interviewed.

The opinions of respondents elicited in each category (A to E) are presented below. General statements are offered which summarise the responses which were given (respondent references which support each statement are given in parentheses after each statement).

5.3.1 Responses in Category A: The kinds of technical constraint associated with each option (abatement and waste management, waste minimisation, material substitution, recycling)

In terms of Fig 3.3.2, Category A addresses "Implementation of; Waste Minimisation, Material Substitution, Abatement and Waste Management and / or Recycling" and linkages to and from this element.

Responses fell into two broad sub-categories:

Availability and ease of implementation

Achievement of environmental improvement versus cost

Availability and Ease of Implementation:

These responses are analysed in Section 5.4 as pertinent to questions P3 and P5 since they provide detail about mechanisms by which Waste Producers implement different waste options.

Firms are limited by availability of options (4a, 4b, 16, 22), which are tried and tested (1, 16). This includes availability of options from technology suppliers (4a, 4b, 16, 22) and those which can be developed in house (4a, 4b, 22).

For Abatement and Waste Management:

Abatement technology can be easily designed and developed by firms which provide plant and equipment (1).

Abatement options can implemented without redesigning established plant (1).

Not all materials collected by abatement are acceptable as wastes at established waste management facilities (22, 4c).

New landfill and incineration facilities can accept a diverse range of materials for waste management (1).

For Waste Minimisation:

Waste minimisation options usually require new plant (1, 10, 22), or reconditioning of existing plant which would require plant closure (22). Waste minimisation is limited by whether existing plant can be easily adapted (4c, 9), without adversely affecting product quality due to materials passed on in the product or removed from the product (4c).

New plant designs which radically reduce wastes and emissions take years of development and testing before they can be offered for sale. In the absence of subsidy for such designs, many remain undeveloped and those that are developed are expensive (1). Smaller firms do not retain expertise required to construct or modify plant and are limited to options which they can purchase (20).

Note that although some forms of material substitution may reduce wastes with less upheaval, reports of such options are interpreted as related to material substitution only.

For Material Substitution:

Use of alternative materials is limited to plants which can easily incorporate them (1, 4c). Alternative materials can influence emissions, product quality and wastes arising (4c).

Material substitution options can be easier to implement if suppliers develop more specialised materials. Customers must be prepared to pay more for such materials than for more generic materials since the latter can be processed on a larger scale (22).

For Recycling:

Recycling requires development of central facilities for particular kinds of material (20). Only larger firms can afford to develop recycling facilities and they have tended to employ such facilities in house as a form of waste minimisation (20). There is a general lack of recycling infrastructure in the UK due to absence of subsidy for its development (22).

Although new manufacturing plant could be designed to process imported waste materials, no-one wants new plant that relies on unstable sources of material (1). An exception is incineration with heat recovery which is robust regarding material inputs (1).

As with material substitution use of recycled materials is limited to plant which can easily incorporate them (1, 4c). Recycled materials can influence emissions, product quality and wastes arising (4c).

As with abatement, not all wastes arising are acceptable materials for recycling (4c)

Achievement of Environmental Improvement Versus Cost:

These responses are analysed in Section 5.4 as pertinent to questions P2 and P4 since they provide detail about benefits of different waste options recognised by Waste Producers. "Achievement of environmental improvement at lowest cost" is also taken to be a low level objective of Waste Producers pertinent to question P1.

Respondents also said that firms are constrained by cost when considering options for environmental improvement. Only one respondent argued that environmental improvement is an end in itself and that firms can rely on their customers to pay for increased costs (12). Other respondents said that firms are constrained to adopting "lowest cost" options which yield "required environmental improvements" (14, 16, 21, 23).

Respondents mentioned the following factors as determinants of "required environmental improvements":

Emission standards imposed by plant licences (2a, 2b, 2c, 16, 21, 23,)

Selection of options identified in HMIP guidance or by consultants (2a, 2b, 2c) or by negotiation at planning stages for new plant (16)

Larger firms consider regulatory standards likely to be enforced during the expected lifetime of a plant (23)

Selection of options which reduce pollution at source (19)

Respondents mentioned the following factors as determinants of "lowest cost":

Savings or revenue generated by options (an option may pay for itself) (16)

Larger firms account for costs and benefits over the lifetime of a plant (23)

Smaller firms cannot afford long term investments and only consider immediate costs and benefits (20, 23)

Respondents mentioned the following factors related to each option type which are important for assessing environmental improvements and costs.

For Abatement and Waste Management:

Abatement contributes to satisfying emission standards (21, 22).

Abatement equipment is relatively cheap (20).

If harmful materials are collected they must be safely managed (19, 22). Unfortunately there are no completely safe waste management options (19).

Waste management is expensive for harmful materials (20).

Waste management prices are rising (22, 23) due to new standards being introduced (22).

For Waste Minimisation:

Waste minimisation contributes to satisfying emission standards (21). Waste minimisation is also the best option for reducing pollution at source (19).

Waste minimisation options are relatively expensive (1, 20)

For Material Substitution:

Material substitution contributes to satisfying emission standards (21). Material substitution can reduce pollution at source if the materials that are replaced are from polluting forms of resource extraction (19).

As mentioned above, substitute materials may be expensive (22). For smaller firms with little purchasing power this cost increase is compounded by higher prices charged for smaller orders (20).

For Recycling:

Internal recycling (a form of waste minimisation) can contribute to satisfying emission standards but external recycling does not. Although recycling processes may cater for abated emissions, the recycling process itself must satisfy emission requirements. Emissions cannot be offset against any emission reductions (below regulatory limits) achieved in primary processes that supply wastes (21).

Recycling may contribute to reducing pollution at source if materials replaced are from polluting forms of resource extraction (19).

Smaller firms cannot afford to develop recycling infrastructure. The larger firms, that can afford to, tend to focuss on internal recycling (23).

5.3.2 Responses in Category B: Relationships between an operation where change is to be considered and an organisation's strategic considerations.

In terms of Fig 3.6, responses in Category B provide detail about Waste Producer Policy. In Section 5.4, this information is analysed in terms of Question P1 as providing information about the goals and objectives of Waste Producers as well as conditions and decision criteria relevant to Waste Policy formulation and

implementation from the Waste Producer perspective. However, some particular responses also provide information which addresses other questions (these responses are identified below).

One key consideration mentioned for operations where change is to be considered is whether plant concerned is new (or about to be reconditioned) or old (2a, 2b, 2c, 4a, 4b, 4c, 10, 12, 16, 20, 21). Note that HMIP consider that new plants should be regulated according to BAT rather than BATNEEC. This distinction matters for the following reasons:

Expected plant lifetime influences the amount of environmental improvement required and the evaluation of the costs of change (achieving, environmental improvement at lowest cost is a Waste Producer objective whilst lifetime of plant is a circumstance pertinent to Waste Producer Policy). Change should be considered in terms of:

Regulations likely in the future as well as those in force now (2b, 4a, 4b, 4c, 10, 12)

Risks of environmental incidents assessed over the expected plant lifetime (2a)

Costs of change evaluated over the expected plant lifetime (2a, 2c, 4)

If change involves acquisition of new plant or reconditioning of old plant, then the following considerations apply:

Whether improvements should be designed into plant or whether plant should be designed to be easily adapted (2c). Options that require structural change should be pursued at early stages of development or during refurbishment, even if regulations won't require such changes for a few years (12). This usually applies to waste minimisation and process changes required for material substitution (4c, 20).

Improvements over and above those required by regulations can be achieved. Such improvements can cause regulators to impose new standards that competitors will have to comply with (2a, 22). It helps to negotiate such matters with regulators early on (10). Skills and techniques developed can then be exported to other firms (20, 22). There will however be a time lag before new standards are imposed (22).

Where competitors in the same sector are responding slowly to regulations, it may be better to achieve only marginal improvements at lower cost (10, 22).

New plant, or plant undergoing significant change will be subject to stricter standards than old plant (21). This is especially true for greenfield developments but less true for developments in long established industrial areas or on derelict land (16).

If change involves existing plant, then the following considerations apply:

Regulatory standards are less strict for established plant (16, 22). Often it's only Health and Safety Inspectors that demand improvement 16).

Choices are limited to:

Closing down plant (9, 10)

Reconditioning plant which is worthwhile if the plant will last for several years (10) or if new plant operating to stricter standards would have to be built (21)

Adopting abatement options which are cheapest in the short term (4a, 4b, 4c, 10).

Other considerations mentioned include:

Knowledge and skills (1, 4b, 4c, 11)

(These responses are associated more with implementation of waste options than Waste Producer objectives and are analysed in terms of Question P5 in Section 5.4)

Knowledge of materials and wastes involved in a process is useful for identifying appropriate facilities for waste disposal and putting a price on wastes. Such information may be presented as a "waste audit". Putting a price on waste allows cost comparisons between low and high waste options. One respondent said that regulators look favourably on firms which can provide a "waste audit".

Knowledge of how to modify and maintain processes can enable firms to reduce wastes and/or emissions. Smaller firms especially do not tend to retain personnel with appropriate skills and knowledge for addressing problems in house.

Firms are structured to develop established areas of business. People with appropriate skills and knowledge do not tend to apply them to environmental problems. Even if staff are aware of environmental issues they may not consider it to be their role to instigate appropriate changes.

Customers (4b, 4c, 20)

(These responses provide further detail about Waste Producer goals and objectives)

Firms "near to the market," are keen to satisfy environmental demands of consumers. If the firm is a large purchaser (eg a supermarket chain) then they can also demand environmental standards to be met by their suppliers. Firms in "high profile"

industries (such as chemicals) are also keen to produce more environmentally friendly products.

In some sectors, regulatory agencies have convinced large firms to improve environmental performance. Such firms are willing to pay more for goods produced to better environmental standards by their suppliers. Marketing of improvements achieved by larger firms also raises the environmental expectations of customers for the sector as a whole.

Stakeholder interests (4b, 4c)

(These responses also provide further detail about Waste Producer goals and objectives)

The following kinds of stakeholder are concerned that firms they are involved with are secure against risks due to environmental liabilities;

Holding firms considering firms for take-over
Investors
Merger partners
Insurers

In the UK, insurance firms only offer cover for "sudden" environmental damage. Legally firms are still liable for consequences of "gradual" environmental damage.

Capital (4b, 4c)

(These responses also provide further detail about Waste Producer goals and objectives)

Although firms do authorise expenditure which is necessary to avoid breaking the law, there are cases when extra spending can enable options that are less expensive in the long term. In such cases, firms expect good returns on investments. This presents three kinds of problem;

A "project champion" is needed to make the effort to show that returns are possible

Returns on environmental spending are difficult isolate

A step-wise plan may involve re-investing returns which can be politically difficult to recover from internal departments involved

Quality (4b, 4c, 24)

(These responses identify quality as pertinent to Waste Producer goals and objectives and also identify quality problems associated with

implementation of particular waste options pertinent to Questions P3 and P5)

> Firms are biased against use of recycled materials because they are concerned that product quality may suffer.
>
> Some options that reduce wastes at source also impair product quality. For example, reduced rinsing of dyed textiles reduces discharges to water but makes the finished product more likely to run.

5.3.3 Responses in Category C: The risks of non-compliance regarding strictness of legislation and degree of enforcement

This category directly addresses linkages between Legislative Agencies and Waste Producers (represented in terms "Regulatory Mechanisms" in Fig 3.6). Although this category was intended to address "Costs and Benefits Appreciated by Waste Producers" as a consequence of "Regulatory Mechanisms," most respondents addressed issues more pertinent to the Legislative Perspective and the process by which particular regulatory mechanisms are employed (Questions L3 and L5). However, some responses in this category address goals and objectives of Waste Producers with respect to reasons for seeking environmental improvement which are due to regulatory pressures (Question P1).

Respondents said that environmental prosecutions are scarce (2a, 2b, 4b, 4c, 10, 16). Firms are able to respond to warnings before prosecution is likely (2a, 4b, 4c, 24). Some firms respond to warnings by finding different ways to release pollutants which requires regulators to issue further warnings (24). Respondents said that strict regulatory action (such as prosecution or revocation of licences) is only likely if there is an immediate risk to health or if firms flagrantly ignore warnings (4b, 4c, 16).

Most firms seek to avoid any risk of environmental prosecution (1, 4b, 4c, 12, 14) for the following reasons (relevant to Question P1):

> Large firms do not want a recorded prosecution to damage the firm's image (2b, 4b, 4c, 21)
>
> Small firms cannot afford the cost of fines (4b, 4c, 20)
>
> Directors or owners of firms are liable for any costs of remediating environmental damage if the firm cannot pay (12, 17)

Requirements for licensing new plant are more demanding than those imposed on existing plant (9, 16, 17, 20). This is pertinent to Questions L3 and L5. Respondents varied in their opinions about whether regulations would become more demanding in the future:

Some thought that Legislation is inherently weak since regulators must identify alternatives prior to prosecution and that such alternatives cannot involve excessive cost (such as overhaul of plant) (1, 16).

Some thought that there is considerable uncertainty about whether future regulations will demand significant improvements (10, 22).

Some thought that regulations will become more demanding (2b, 12).

Respondent 14 argued that although no firm wants to be prosecuted, most firms seek to remain just one step ahead of regulations (pertinent to question P1). This is possible by keeping up with whatever changes are being pursued by competitors.

Respondent 10 said that uncertainty about future regulations is due to variations between the enforcement of new regulations in different sectors (10). This variation was explained by the legal adviser (17) as due to the process by which new regulations are implemented (relevant to Questions L3 and L5).

New regulations are imposed sector by sector. Conditions to be included in licences are based on guidance notes prepared by HMIP in negotiation with firms active in any given sector. This process can take up to five years. In the meantime, firms are aware of the kinds of change likely and can prepare for it. Once licences are issued, regulations will be strictly enforced. At the time of interviewing, no licences based on the new regime of IPC had been issued (17).

Respondents also thought that standards of regulation varied from Local Authority to Local Authority (1, 4a, 4b, 4c, 9, 20, 21). This is a relevant finding in terms of Questions L3 and L5. Abatement packages are even supplied to cater for the demands of different Local Authorities (21). The following factors were mentioned in connection with Local Authorities:

> The particular preferences and expertise of inspectors varies between Local Authorities (20, 21)
>
> Local issues influence interpretation of legislation. For example, Local Authorities may not wish to prosecute large local employers (16, 21)
>
> Local Authorities do overstep their authority. For example, by delaying licence approval unless a firm takes part in a recycling scheme (4b, 4c, 21). Respondents 4b and 4c recommend legal action in such cases but Respondent 21 thought that firms do not want to risk their reputation even if they are vindicated in the long term.
>
> In some Local Authorities there is little communication between pollution and waste inspectors, and firms may satisfy one inspector by exploiting another. For example, pollutants not emitted may be mixed with wastes sent to landfill (20).

Respondent 9 said that some firms developing new plant seek out Local Authorities with lax planning procedures or purchase existing plant which may be modified without acquiring a new licence.

5.3.4 Responses in Category D: How respondents perform the job of consultancy

This category is relevant to the research in that it highlights the importance of collating information from different sections within a firm and from external agencies which supply goods and services to a firm (such as Waste Managers, Technology Suppliers and Material Suppliers). This information is not used in the analysis presented in Section 5.4 but it does support the modelling activity presented in Chapter Six.

It is useful to refer to two kinds of respondent is this section. These are called "top down" and "bottom up" consultants below.

Top Down Consultants are those that;

usually report to the higher levels of management in a client organisation (usually board members or owners),

often consider general problems of policy for clients,

seek authority from the higher levels of management to interview staff in the client organisation and on occasions to request information from a client firm's suppliers (such as Waste Managers, Technology Suppliers and Material Suppliers) and customers.

Bottom Up Consultants are those that;

usually report to lower levels of manager in a client organisation such as production line managers or buyers,

usually address defined technical problems,

report on options available to solve problems often supplied by the consulting firm or an associated firm.

Note that although some bottom up consultants were not interviewed due to Reason A given in Section 5.2, in some cases it was not realised until interviews were in progress that other respondents were concerned to sell particular products.

Note also that top down consultants occasionally employ bottom up consultants from firms which supply plant to a client firm.

From information gathered in category D it is apparent that respondents 2a, 2b, 2c, 4a, 4b, 4c and 12 are top down consultants whilst respondents 1 and 21 are

bottom up consultants. Respondent 10 seems to perform the roles of both a top down and a bottom up consultant.

Half the respondents (9, 14, 16, 17, 19, 20 22, 23, 24) did not offer information which enabled this distinction to be drawn.

Attempts to correlate the kind of consultant with the kind of information consultants gave in their responses failed to generate findings pertinent to this research.

5.3.5 Responses in Category E: Other information offered

This category is not relevant to any individual element of the conceptual model. Some information though is presented below since it is pertinent to the overall process of Waste Policy formulation and implementation involving Legislative and Industrial Agencies. This information is referred to in Chapters Six and Ten where the overall system is considered.

Responses in this section tended to address how respondents gauged developments likely to occur in the future.

The ways by which consultants decide what regulations may affect their clients in the future include:

> Involvement with HMIP to help determine BATNEEC's and BPEO's upon which regulations will be based (2a, 2b, 2c, 4a, 4b, 4c).
>
> Monitoring of EC Directives which contain standards that will eventually be implemented by HMIP (17).
>
> Subsidy for costs of environmental improvements is not likely as long as the UK government continues its "Market Based Approach to the Polluter Pays Principle" (20).

The trends in industry towards environmental improvement which include:

> As new plant is replaced with old, standards will improve (1). Lack of subsidy for improvements may leave established smaller firms lagging behind newer or larger competitors (20).
>
> As standards based on IPC regulations spread to more sectors, standards will improve. Some sectors may improve more slowly because the processes involved are less environmentally damaging (1, 14, 21)
>
> Local Authorities are not powerful enough to force large local employers to improve radically or to significantly improve standards in long established industrial areas (1, 16). Costly

developments away from established areas are likely to be limited to lighter forms of industry, such as office based work (16).

Although some firms are proactive and would like to see more prosecutions, other firms are only improving slowly and would like to see less (10).

Respondents also mentioned the kinds of skills and resources they employ. These include;

> Laboratory facilities (where the consultancy is strongly focussed on solving material problems) (12).
>
> Networking skills (since understanding of "the American Experience" shows the importance of consulting staff at all levels in a firm) (2a).

5.4 Interpretation of Results

The information presented above (Section 5.3) provides a rich picture of issues faced by firms considering environmental improvement to their operations. This rich picture must be interpreted in the context of this thesis. This may be done by re-presenting the information in the context of Waste Producer questions (and two of the Legislative questions). Remember that these questions correlate with the conceptual model according to Fig 3.4. Interpreting the research findings to address these questions serves to filter the information which is pertinent to the conceptual model of Waste Policy formulation and implementation.

P1. What are the goals and objectives of industrial Waste Producers to which recycling could contribute?

Information relevant to this question is primarily located in Section 5.3.2 with the following exceptions:

> "Improving environmental performance at lowest cost" is inferred as a low level objective from Section 5.3.1 where it is reported as a key constraint associated with implementing waste options.
>
> Some organisational objectives associated with avoiding prosecution are reported in Section 5.3.3.

Fig. 5.1 presents an interpretation of the information relevant to the goals and objectives of Waste Producers. This diagram assumes that firms wish to maximise profit from established forms of business and/or diversify into new markets. These goals are reduced to an objective of improving environmental performance at least cost. This reduction relies on four rationales each of which is supported by evidence provided by the respondents.

The four rationales (satisfy stakeholders, satisfy regulatory agencies, remain competitive and exploit in house resources) are stipulated by the researcher and are not the only set of rationales which could be inferred from the evidence.

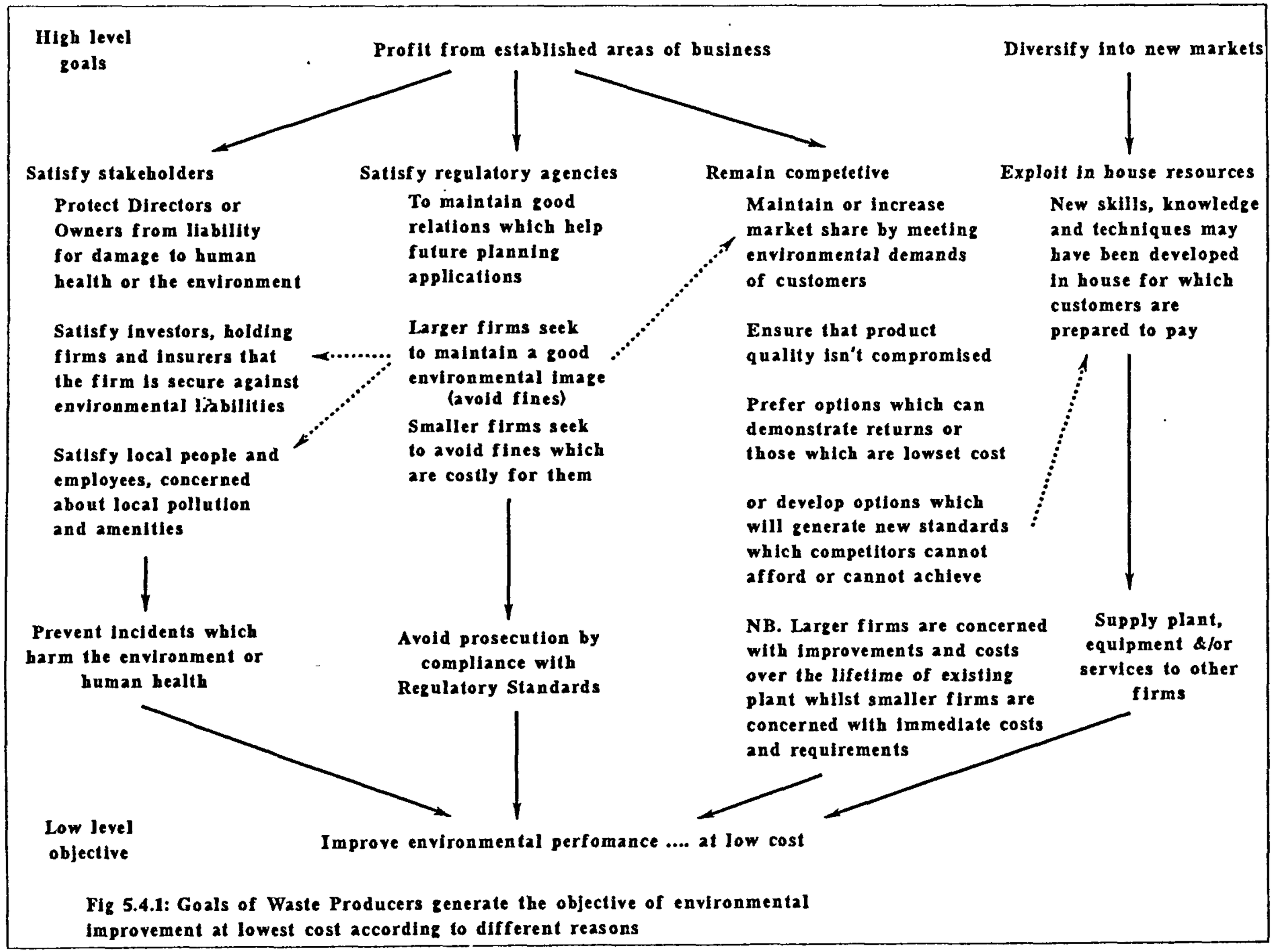


Fig 5.4.1: Goals of Waste Producers generate the objective of environmental improvement at lowest cost according to different reasons

These rationales are not mutually exclusive. In fig 5.4.1 dotted lines are used to demonstrate some examples of how elements from separate columns are interactive.

The important feature of the diagram is that it shows that *options which improve environmental performance at lowest cost contribute to satisfying higher level goals of Waste Producers.*

Whether the amount of environmental improvement sought is determined by immediate or long term satisfaction of regulations or whether it is determined by a desire to satisfy insurers that the firm is secure against liabilities due to environmental accidents depends on which elements of rationales apply to a given firm.

Similarly, whether lowest cost is determined in terms of immediate or long term costs and whether concerns about product quality or the possibility of pushing environmental standards to the detriment of competitors is accounted for depends on the circumstances of the firm and its confidence regarding the likelihood of improved standards arising from improvements.

P2. What benefits of recycling industrial wastes are recognised by Waste Producers as contributory to achievement of their goals and objectives?

Information relevant to this question is located in Section 5.3.2 in the particular sub-category "Achievement of Environmental Improvement Versus Costs" which was identified by respondents as a key constraint. This sub-category is rephrased above as the lowest level Waste Producer objective as is appropriate for a set of information relating to benefits of recycling (and other waste options) recognised by Waste Producers.

The only positive benefit of recycling mentioned was that it could contribute to reducing pollution if materials replaced are from polluting forms of resource extraction. In the absence of regulatory mechanisms which provide financial returns if such a form of recycling can be demonstrated, this benefit would only be recognised by the most altruistic of firms.

Disbenefits mentioned include:

> Use of recycled materials can impair product quality and influence emissions and wastes arising from processes they are used in.
>
> Plant designed to recycle wastes relies on an unstable source of materials.
>
> Recycling plant must satisfy emission standards without receiving credit for any emission reductions which recycling enables in processes which supply waste materials.
>
> Smaller firms that may wish to use recycling facilities cannot afford to develop them (larger firms are more likely to focus on waste minimisation).

P3. What mechanisms are deployed to implement recycling of industrial waste by Waste Producers?

Information pertinent to this question is primarily located in Section 5.3.1 in the particular sub-category identified as "Availability and Ease of Implementation" (with the exception that consequences for product quality is a finding of Section 5.2.2.).

Recycling requires development of central facilities for particular kinds of material.

Use of recycled materials is limited to plant which can easily incorporate them.

Supply of recycled materials requires identification of appropriate recycling facilities (not all wastes are acceptable for recycling purposes).

Use of recycled materials may influence product quality.

P4. What benefits of other options are recognised by Waste Producers as contributory to achievement of their goals and objectives?

Information relevant to this question is located in Section 5.3.2 in the particular sub-category "Achievement of Environmental Improvement Versus Costs" which was identified by respondents as a key constraint. As with Question P2 this seems appropriate since benefits should be recognised according to policy objectives.

Abatement, waste minimisation and material substitution can contribute to satisfying regulatory agencies.

Waste minimisation and some forms of material substitution (those which replace materials from polluting forms of resource extraction) reduce pollution at source.

Abatement equipment is cheap, but abated emissions increase waste management costs especially if harmful materials are involved.

Waste minimisation options are expensive, but reductions in wastes produced can generate savings in waste management costs over time.

Substitute materials may be expensive especially for small firms placing small orders.

P5 What mechanisms are deployed by Waste Producers to implement other options?

Information pertinent to this question is primarily located in Section 5.3.1 in the particular sub-category identified as "Availability and Ease of Implementation" (with the exceptions that knowledge and skill limitations and relevance of product quality are findings of Section 5.2.2.).

Abatement

Abatement technology is available from plant and equipment suppliers.

Implementation of abatement options does not involve redesign of plant.

Landfill and incineration facilities can be identified which accept many, but not all, kinds of abated emissions.

Waste Minimisation

Waste minimisation technology is not fully developed by plant and equipment suppliers.

Implementation of waste minimisation may involve construction of new plant or closure and reconditioning of established plant. This requires considerable in house expertise and/or finance.

Waste minimisation may influence product quality if materials are passed on in, or removed from, products.

Material Substitution

Existing plant must be able to, or be adapted to, incorporate new materials, or materials must be customised by suppliers to be usable in existing plant.

L3 and L5 What legislative mechanisms are intended to encourage recycling and other options which contribute to the achievement of environmental goals and objectives in the UK?

The respondents added to information presented in Chapter Four by referring to regulatory influences experienced by their clients in Section 5.3.3.

Legislative mechanisms encourage stricter standards for new plant than for existing plant.

Local Authorities vary in their interpretation and enforcement of legislation giving rise to regional variations in strictness of standards.

Local Authorities are generally less able to prosecute large local employers and firms operating in long established or derelict areas.

Regulations are stricter in certain industrial sectors than others. This may be due to differences between sectors regarding timing of implementation of new legislation, or it may be due to some sectors being considered as requiring less improvement.

From the above analysis, the research findings can also be considered in terms of Questions P6 and P7.

P6 What are the differences between recycling and other options with respect to:

(a) achievement of environmental goals and objectives of Waste Producers?

(b) mechanisms deployed to implement each kind of response by Waste Producers?

The four options identified for improving environmental performance of Waste Producers differ in respect to:

The ways in which they contribute to satisfying *environmental improvement at lowest cost.*

The mechanisms which Waste Producers must deploy to implement them.

Furthermore, different kinds of firm appreciate differences in different ways. Relevant attributes of Waste Producer firms include:

Size of firm influences planning horizons and whether the firm is more concerned about its image or the cost of fines.

Whether the firm operates existing plant or intends to operate new plant influences;

the strictness of regulations to be complied with

the viability of options which involve redesign of plant and/or those which have long pay back periods.

If the firm seeks to push environmental standards in its sector beyond the reach of competitors then it may attempt to achieve more environmental improvement than if it seeks to respond no more than the majority of competitors do.

If the firm seeks to diversify into new markets for environmental goods and services, then it can balance the development cost of options against expected returns.

The particular sector which a firm operates in relates to the strictness of regulations imposed, the expectations of customers and the availability of environmentally improved goods and services from suppliers.

A firm's location may influence strictness of regulations imposed if it is regulated by a Local Authority.

P7: Under what circumstances do differences between recycling and other options matter to Waste Producers for the satisfaction of environmental goals and objectives and for implementation of responses?

Some differences between firms are recognised by the legislative policy of the UK Government which seeks to empower firms to choose options which are most suitable to them whilst achieving prescribed standards regarding emissions. Other differences arise from understandable variations in enforcement of regulations between different industrial sectors or from unfortunate but unsurprising consequences of delegating responsibility for enforcement to Local Authorities.

However, one difference identified is that legislative mechanisms fail to recognise certain benefits of recycling. In particular, plant which recycles waste materials must satisfy emission requirements applicable to plant which processes similar primary materials. This is despite the fact that recycling when considered at a broader level avoids emissions due to polluting forms of resource extraction and may also provide waste management for abated emissions which is less polluting than established forms of waste management. This argument may also be applied to waste minimisation options and some material substitution options.

Although waste minimisation would seem to be the best option for addressing pollution problems at source and reducing pressures on material and waste management resources, this option seems best suited to larger firms and/or firms intending to open new plant. Smaller firms operating established plant are more suited to options involving less investment and requiring less internal expertise. Abatement is one such option which, unfortunately requires use of waste management services which are becoming more expensive. An alternative to waste management would be recycling except for a shortage of recycling infrastructure. Smaller firms cannot afford to invest in infrastructure whilst larger firms are developing waste minimisation options which avail them of the need for recycling infrastructure.

These circumstances make the differences matter because they prevent some firms from adopting options which reduce pollution at source (an objective of the UK Government). This is because all firms are not able to respond as perfect economic actors. The market oriented strategy of the UK government relies on firms having access to a choice of option types and on them having good information about likely costs and benefits of different option types. However, smaller firms suffer from a shortage of disposable capital and a lack of in house skills to develop costly waste minimisation options. Recycling options in general are limited by availability of suitable infrastructure.

5.5 Conclusions

Important aspects of Waste Policy formulation and implementation are identified in this chapter based on interviews conducted with environmental consultants. The soft survey approach employed sometimes provided conflicting information (such as conflicting responses as to whether environmental legislation is stringent) which is not surprising given the complexity surrounding issues investigated.

The information provided by consultants required some re-structuring to be useful in the context of this research. This was achieved using Waste Producer and Legislative questions which relate to elements of the conceptual model of Waste Policy formulation and implementation. With hindsight, it would be possible to design a more structured interview approach (or even a questionnaire) to provide further support for and to enhance the interpretation offered. However, this research activity is not the sole focus of this thesis and time was not spent extending this line of enquiry in the interest of developing other aspects of the research.

The important aspects of the interpretation presented in Section 5.4 are of the following types:

General objectives of Waste Producers are identified as contributory to profit goals.

Rationales are identified according to which particular conditions and attributes applicable to Waste Producer firms generate particular interpretations of objectives.

Different kinds of mechanism by which firms can implement different kinds of waste option are identified.

Different kinds of benefits (or disbenefits) which firms may anticipate from implementing different kinds of option are identified.

Some conditions relevant to Waste Producer Policy formulation and implementation are shown to be dependent on particular features of regulatory mechanisms employed in the UK.

A first step is taken to identify incongruence between Waste Policy formulation and implementation as pursued by Legislative and Waste Producer agencies in the UK (interpretation with respect to Question P7 in Section 5.4).

The interpretation of results presented in Section 5.4 and the summary of findings presented in Section 4.9 are used in Chapter Six to consider modelling tools which can be applied to resolve some of the detail concerning Legislative and Waste Producer Policy formulation and implementation processes. These tools are used to derive similar "modelled" information that addresses Legislative and Waste Producer questions which can be compared with

information presented in Sections 4.9 and 5.4 to determine limitations of the tools developed.

In the following chapter a model is presented which represents some of the differences between the options outlined in this chapter. Subsequent chapters present a case study which considers an opportunity for waste managers to recycle materials from the construction waste stream and which outlines some considerations from the waste manager perspective relevant to recycling and waste management options in general.

CHAPTER SIX

Further Development of the Conceptual Model

6.1 Introduction

The interest of Blue Circle Waste Management Ltd (BCWM) in recycling is broad in that BCWM recognise that Legislative Agencies and Waste Producers play significant roles that influence conditions under which recycling may or may not be preferable as an alternative to landfill and other waste management options.

In Chapter Three a conceptual model is proposed which shows how Waste Policy formulation and implementation is distributed between Legislative and Industrial Agencies. Chapters Four and Five present research which identifies further detail regarding the system modelled. The research questions presented in Section 3.2 are used in Sections 4.9 and 5.4 to interpret research findings in terms of pertinent findings regarding Waste Policy formulation and implementation that are relevant to recycling.

One way to consolidate the information presented in Sections 4.9 and 5.4 would be to map pertinent information arising from these interpretations onto the elements of the conceptual model according to the association between model elements and research questions represented in Fig 3.4 (reprinted on p.115 for easy reference).

For example, consider the legislative objective of "limiting pollution at source." This objective is associated with the particular regulatory tool of the emission standard which is deployed by two sets of Legislative Agencies; Local Authorities and Her Majestey's Inspectorate of Pollution (HMIP), according to the principles of BATNEEC and BPEO respectively. These agencies employ the legislative mechanisms of; licensing, inspection and prosecution to promote adoption of best practices in waste producing firms. Waste Producers appreciate costs of polluting activities arising from charges made for licences, costs of employing monitoring techniques and costs of taking whatever minimum action is necessary to meet regulatory requirements. However, firms may take the opportunity to adopt further improvements for many reasons including;

Satisfying stakeholders (such as insurers) that the firm is secure against environmental liabilities

To exploit in house skills in order to develop new standards of best practice which competitors will have to match or improve on

To remain competitive by satisfying environmental demands of customers

To save money by reducing wastes as well as emissions

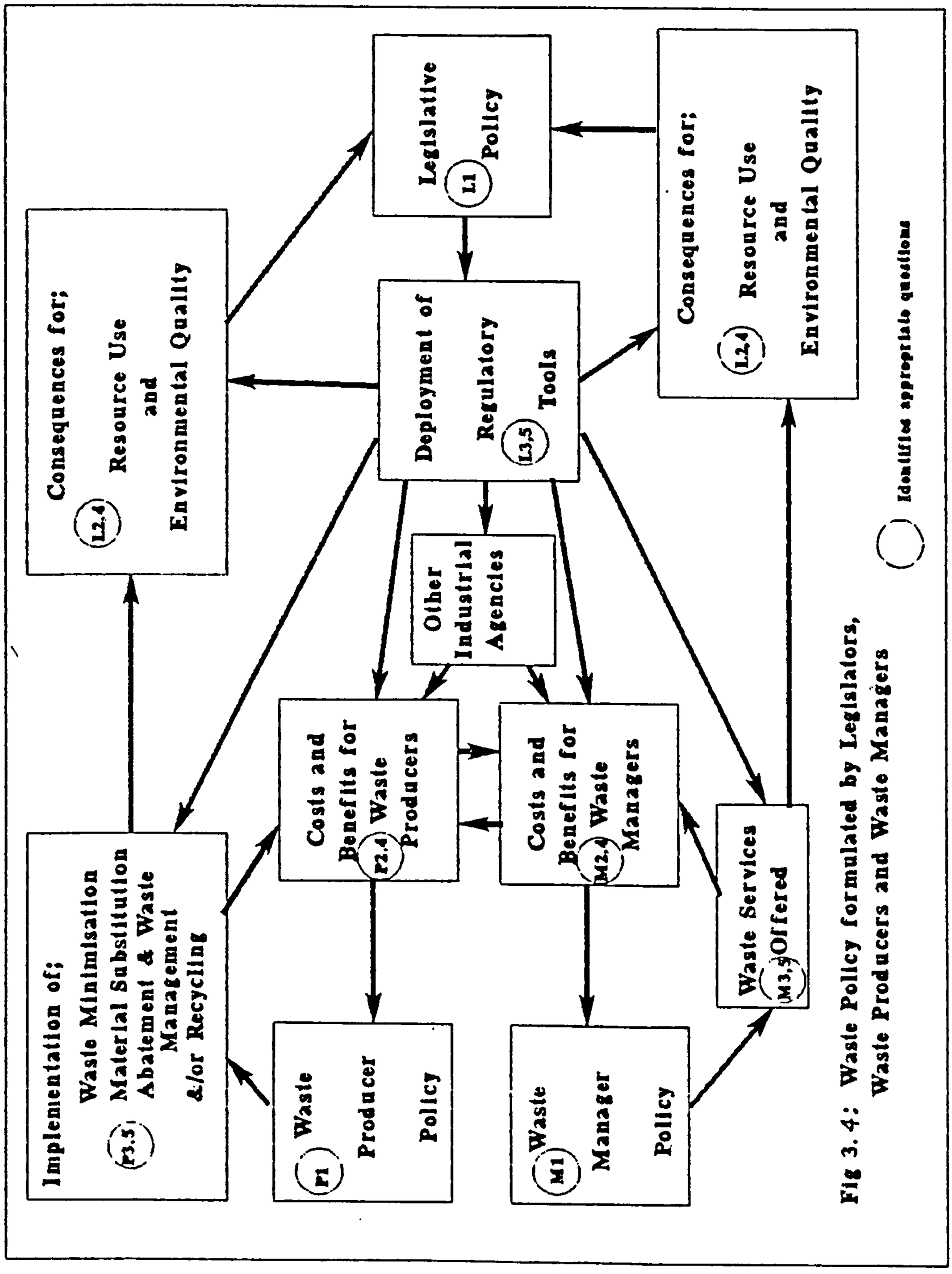


Fig 3.4: Waste Policy formulated by Legislators, Waste Producers and Waste Managers

Regulation of firms by Local Authorities raises issues concerning diverse interpretations of environmental legislation. Although process guidance notes are issued to all Local Authorities (to promote uniform interpretation of standards), some Local Authorities do seem to balance other local concerns, such as employment, with concerns about environmental problems.

For just one legislative objective and the regulatory tools deployed to promote change in industry, a complicated set of associated problems and issues is generated. Furthermore, these problems and issues are not independent of other legislative objectives. For example, savings appreciated by firms for reducing waste are enhanced by increases in waste management prices. These increased prices are due to process standards imposed by Waste Regulation Authorities on waste management operations and from a requirement to ensure that Waste Managers are "fit and proper persons" to prevent environmental pollution and harm to human health (this has lead to consolidation by more professional firms in the landfill sector which also contributes to higher waste management prices). Concern of Local Authorities about environmental issues is associated with their role in maintaining local environmental quality standards (yet another distinct legislative objective).

Although each element of the conceptual model can be resolved in further detail (eg by listing legislative objectives within the model element identified as Legislative Policy) such an exercise only contributes to understanding if linkages between such sub elements are individually identified to highlight interconnections which give rise to problems and issues pertinent to Waste Policy formulation and implementation. However, interdependencies (of the kind outlined above) of issues involve many linkages between sub-elements. Indeed it seems that if one issue is to be represented in this fashion then all issues must be included. The output of an exercise to represent more detailed linkages pertinent to Waste Policy formulation and implementation directly in terms of the conceptual model would be a diagram of extreme complexity that complicates rather than enhances understanding.

An alternative approach is to simplify issues and problems identified in Phase One of the research. A conceptual device called "material balancing" is presented in Section 6.2 which enables such a simplified interpretation. A subsidiary conceptual device representing skills and resources of Waste Producers is presented in Section 6.4.

The material balancing model is applied in Section 6.3 by considering different legislative objectives and associated regulatory tools in terms of appropriate sets of boundary conditions within which to apply the material balancing model in order to represent pertinent issues and problems.

In Section 6.4, problems and issues faced by Waste Producers are considered by applying the material balancing model for boundary conditions enclosing waste producing firms.

In Sections 6.3 and 6.4, the material balancing model is used to derive propositions which address research questions pertinent to Waste Producer and Legislative perspectives. Objectives associated with Legislative and Waste Producer Policies are taken to be those interpreted from findings of Phase One of the research (Section 6.3.1 and 6.4.1). The material balancing model is used to identify differences between waste options perceived from Legislative and Waste Producer perspectives according to appropriate objectives (summarised in Sections 6.3.6 and 6.4.6). Such

differences are interpreted in terms of conditions identified in Phase One of the research (sections 6.3.7 and 6.4.7). Such conditions are research findings that are not incorporated into the material balancing model.

In Section 6.5, issues and problems identified using this approach are outlined in a broader context spanning Legislative and Waste Producer perspectives. One such issue is that consideration of Waste Producer and Legislative Perspectives suggests that recycling may not be implemented due to a lack of recycling infrastructure. This lack of infrastructure is seen to be a consequence of understandable rationales of Waste Producers in the light of conditions and regulatory requirements applicable to them and lack of subsidy for recycling facilities understandable in terms of legislative objectives.

In Section 6.5, it is argued that Waste Managers do not experience the same conditions and regulatory requirements and thus may be well positioned to develop recycling infrastructure. The potential role of Waste Managers in this respect is the subject of a case study conducted as phase two of the research (Chapters 7 through 9).

6.2 Material Balancing

In Chapter Five, it is shown that from an industrial perspective waste options differ both in terms of how they contribute to the goals and objectives of Industrial Agencies and in terms of the mechanisms deployed by Industrial Agencies to implement them. One tool referred to by consultants to describe some differences is "material balancing." This tool is used in this section to;

> Objectively define waste option types in terms of changes to material flow which each option type enables and whether options require changes to waste producing processes.
>
> Identify changes to material flow and to waste producing processes with costs and benefits appreciated by Waste Producers.
>
> Identify changes to material flow enabled by each option type with contributions to satisfying legislative objectives.

A material transformation process is represented in Fig 6.1, showing material inputs and outputs for a process. **"Material balancing"** demands that input quantities equal output quantities under all circumstances. In other words any change in one input or output must be compensated for by changes in other inputs and outputs.

Differences between the four options are summarised in Table 6.1 in terms of changes required to inputs, outputs or to the process itself.

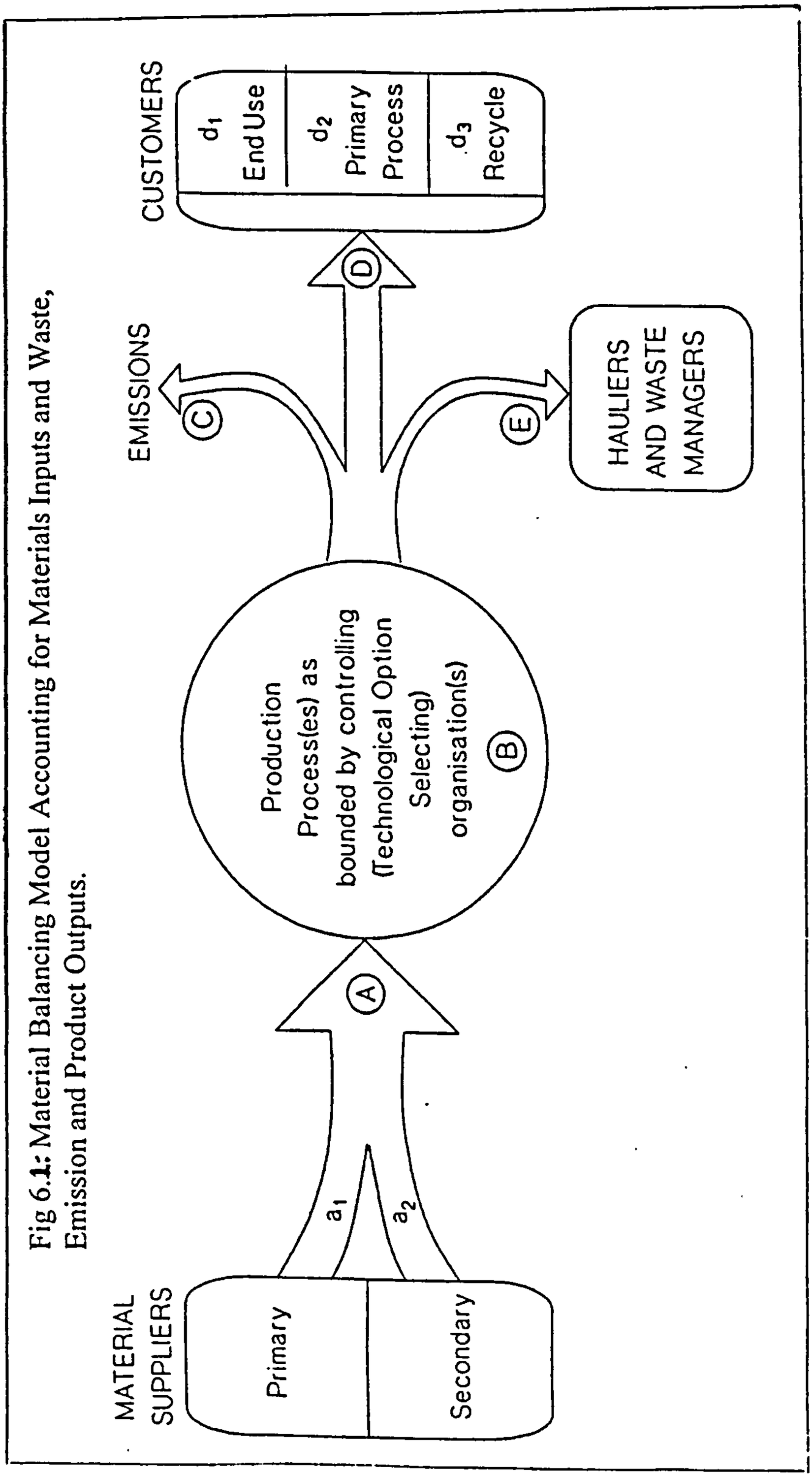


Fig 6.1: Material Balancing Model Accounting for Materials Inputs and Waste, Emission and Product Outputs.

Table 6.1: Changes Associated With Different Types of Waste Option (See Fig 6.1)

Option Type	Material Flow Changes
Waste Minimisation	Change B reducing C &/or E per unit of D
Material Substitution	Change A reducing C &/or E. May require change in B. May alter quality of D
Abatement	Divert C to E
Recycling	Divert E to D (d3) or replace a1 with a2. May require change to B.

The material balancing model is useful for defining the four option types. Distinctions between option types are drawn in Sections 6.3 and 6.4 in order to improve understanding of the role of recycling as one waste option amongst the set of four identified.

This model can be applied using various boundary conditions. A "boundary" may be considered wherever it is meaningful to talk of material inputs balanced (in terms of mass) against product, emission and waste outputs. A "boundary" then, can be conceptually applied around a production line, a factory, a geographic region, an industrial sector or even a nation.

Note that particular activities may be considered as different options under different boundary conditions. For example, consider a factory which prevents evaporation of solvents into the atmosphere by collecting and storing used solvents. A waste haulier collects the solvents as wastes but sells them to a solvent manufacturer for recycling. The solvent manufacturer may sell a lower grade product made from recycled solvents at lower price to the original factory. Within the boundary of the factory two distinct activities are pursued; **Abatement with waste management** and **material substitution**. The material suppliers may consider themselves as purchasing secondary materials, a form of **external recycling**. Placing a boundary around the whole system represents these activities as **waste minimisation**.

Each material flow change listed in Table 6.1 is associated with a change in costs. For example, reducing waste output results in reduced running costs for the operation. Changing the process itself may result in a change to its running cost and/or an increase in capital cost.

Application of this technical model demands stipulation of boundary conditions. The three perspectives outlined in Section 3.2 enable consideration of three sets

of boundary conditions within which to apply this model in order to shed light on the research questions posed in Section 3.2.

6.3 Applying the Material Balancing Model From The Legislative Perspective

This section addresses the technical linkages of Fig 3.4 (p.115) to and from the three legislative boxes (related to questions L1 through L5) which deal with legislative aspects of Waste Policy formulation and implementation.

The material balancing model suggests the following properties for each option type.

Waste Minimisation

Any waste removed is genuinely eliminated in terms of environmental and resource consequences. Logically, any materials incorporated into products are diverted from becoming wastes. Zero waste minimisation suggests a process which produces waste and nothing else from previously useful materials. Although waste minimisation is often seen as something which Waste Producers do not always pursue, the objective definition offered by the material balancing model indicates that all waste producing processes are waste minimising to some degree if they produce a useful product.

Material Substitution

Emissions and wastes generated may be different. Where less scarce materials replace scarce materials there are resource conservation benefits. Where less polluting materials replace polluting materials there are environmental quality benefits. Where wastes arise, environmental consequences depend on relative material properties and facilities available for elimination of any problems arising.

Abatement coupled with appropriate waste management

In a sense all accumulated wastes have been abated from becoming a problem (eg. locally dumped). This option can be thought of as the default option. The contribution to environmental conservation of this option depends on the environmental damage averted by waste management facilities when compared with discharge to the environment at source. This option does not contribute to resource conservation.

Recycling

This option shares similarities with the Abatement and with Material Substitution in that it involves removal of waste and generates an alternative source of materials. Recycling can also be considered as Waste Minimisation within broader boundary conditions and indeed can only be of benefit from the Legislative Perspective if this can be shown.

The issue apparent from the above is that all four options can contribute to resource and environmental conservation and hence to the goal of Sustainable Development. Whether one option or other does so better would appear to depend on materials, processes and disposal facilities involved rather than any necessary pecking order.

This model can be applied to the Legislative questions posed in Section 3.2. Preliminary research suggested that UK legislation sought to promote improvements to waste practice through indirect rather than direct intervention. This is significant for the propositions derived for questions three and five.

6.3.1 Question L1: What are the goals and objectives of Environmental Legislation in the UK to which recycling could contribute?

The material balancing model demonstrates that Recycling can be consistent with the goal of Sustainable Development in as much as it enables more resource and/or environmental conservation per unit of production within national boundary conditions.

The five principles of legislative policy in the UK (summarised in Section 4.9) can be considered as establishing objectives which contribute to the goals of Sustainable Development. These objectives are;

(1) Limiting pollution at source

(2) Maintaining local, regional and national environmental quality standards

(3) Containment of wastes in disposal facilities

(4) Maintaining secure waste streams

(5) A market based approach to the polluter pays principle

These objectives are derived from research into the policies of the UK Government of the day (presented in Chapter Five), rather than from the material balancing model presented in Section 6.2.

6.3.2 Question L2: What benefits of recycling industrial wastes are recognised by legislators as contributory to achievement of legislative goals and objectives?

Regarding the goal of Sustainable Development recycling contributes in two ways.

Firstly recycling contributes to resource conservation in as much as recycling processes generate raw materials (also averting some need to use materials in established forms of waste management) in larger quantity or of greater scarcity than those used in the recycling process.

Secondly recycling contributes to environmental conservation in as much as recycling operations cause less environmental damage than established forms of waste management and materials extraction and processing which recycling replaces.

In terms of objectives identified for legislative policy in the UK the material balancing model suggests the following contributions of recycling:

(1) Limiting pollution at source:

By "source" UK legislation refers to individual industrial plants or parts of plants as "prescribed processes" or processes which produce "prescribed substances." In terms of the material balancing model this means applying boundary conditions around the plant (or part of plant) in question.

Supply of secondary materials for recycling purposes does not influence the emission of pollutants. If materials supplied are abated emissions then it is the implementation of abatement that has contributed to this objective.

Use of secondary materials only contributes to this objective if the secondary materials perform in the process concerned to give rise to less polluting emissions than materials otherwise employed would generate.

In the UK, any plant developed to recycle materials must produce limited pollution (no more than plant which processes similar quantities of similar primary materials) with no account taken of pollution avoided due to industrial sources which recycling replaces (waste management and primary material extraction operations).

(2) Maintaining local, regional and national environmental quality standards:

Applying broader boundary conditions than those considered for individual plants models external recycling options (identified for individual plants) as waste minimisation options (with broader boundary conditions). Recycling can contribute to this objective if it enables emissions to be reduced (and quality standards to be maintained) for a given amount of industrial activity in the bounded area.

For example, consider a brick manufacturer, builders and a clay pit (providing raw materials for bricks) in a regional area for which environmental quality standards are to be maintained. If the brick manufacturer recycles broken bricks returned by the builders, then there may be no benefit in terms of emissions from the brick manufacturing plant since the plant still processes the same amount of material. However, the amount of clay extracted in the area may be reduced resulting in a reduction of environmental harm caused by this source.

Although recycling does not contribute to reducing pollution at source (per unit of production), it does contribute to maintaining regional environmental quality standards by reducing the amount of primary materials extracted (there may also be benefits due to less need for waste management).

(3) Containment of wastes in disposal facilities:

Recycling is an alternative to disposal. As such recycling contributes indirectly to this objective if reduction of wastes sent to waste facilities reduces the amount of waste which escapes from waste facilities and the environmental consequences thereof.

This could happen if wastes recycled are difficult to contain in established facilities (for example evaporation of solvents sent to landfill sites is difficult to prevent), or if waste facilities are better at containing wastes if they operate at reduced rates of input (ie if facilities are operating with higher rates of input than can be safely managed).

On the other hand, the assumption that waste facilities "contain" wastes can be considered as a disincentive for recycling since emissions from recycling processes are not compared with those from waste disposal facilities.

(4) Maintaining secure waste streams:

This objective may be considered by placing the model boundary around the waste producer and the waste manager only.

Recycling contributes to this objective as long as wastes supplied for recycling are suitable for recycling in the particular recycling facilities employed and that wastes are contained during transport.

(5) A market based approach to the polluter pays principle:

Recycling contributes to this objective as long as the economic viability of implementing a recycling option does not depend on subsidy or its mandatory stipulation and is not impaired by subsidy or mandatory stipulation of competing options.

In terms of the material balancing model, this means making polluters responsible for costs of emitting pollutants to the environment. There is a balance to be struck here between pollution costs appreciated due to emission requirements for individual plants which do not recognise some benefits of recycling and costs appreciated due to measures to maintain regional environmental quality standards which can incorporate broader benefits of recycling.

6.3.3 Question L3: What legislative mechanisms encourage recycling of industrial waste in the UK?

The market based approach to the polluter pays principle suggests that recycling should only be encouraged if it is the cheapest way to improve environmental performance. The changes to material input and output shown in Table 6.1 for recycling options may be associated with costs for waste management or recycling services and primary or secondary sources of materials.

Supply of waste materials for Recycling is encouraged if:

Established Waste Management services become more expensive

or

Recycling services become less expensive

Use of Secondary materials from Recycling is encouraged if:

Primary materials become more expensive

or

Secondary materials become less expensive

Stricter operating requirements imposed on waste management operations have increased the cost of established forms of waste management. However, imposition of strict requirements for all industrial operations should also make some recycling services more expensive and/or make secondary materials more expensive. Similarly primary materials processed by operations for which stricter standards are imposed should also make some primary materials more expensive. The economic factors outlined above are not legislative mechanisms but they are legislative consequences which the model represents as important.

6.3.4 Question L4: What benefits of other industrial options are recognised by legislators as contributory to achievement of legislative goals and objectives?

Regarding sustainable development (which may or may not be a legislative goal), the model suggests the following contributions of waste options:

Waste minimisation contributes directly by reducing resource use per unit of production and indirectly by reducing emissions and wastes arising per unit of production. In as much as emissions and established forms of waste management cause environmental damage and/or use resources (for environmental remediation or waste management) the indirect effect is also significant.

Material substitution contributes if:

Less scarce materials are substituted for scarce materials

or

Less polluting materials are substituted for polluting materials.

Abatement reduces emissions and produces more wastes. This option contributes to environmental conservation by reducing Waste Producer

emissions. The materials abated as emissions though must then be **managed appropriately as wastes** if this benefit is not to be wholly diminished by increased emissions at waste management facilities.

Regarding lower level objectives:

(1) Limiting pollution at source:

All the other three options contribute if emission reductions are apparent under boundary conditions applied to a given plant.

(2) Maintaining local, regional and national environmental quality standards.

All options that contribute to limiting pollution at source can contribute to this objective with the following provisos.

Waste minimisation also reduces material use and may provide further benefits due to reduced emissions from polluting forms of resource extraction and processing which are located within the area for which boundary conditions apply.

Material substitution may have similar benefits if sources of substitute materials within the area are less polluting than sources of substitutee materials. However material substitution may pose disbenefits if the opposite applies.

For **abatement** options, benefits achieved in terms of emission reductions at individual plants may be offset by emissions from waste management facilities if they are located within the bounded area concerned.

(3) Containment of waste in disposal facilities

Applying the material balancing model with boundaries around waste disposal facilities suggests that waste options contribute to this objective in the following ways.

By preventing the production of wastes, **waste minimisation** options are not directly associated with this objective. However if the particular waste reduced are difficult to contain in waste management facilities then waste minimisation can be said to contribute to this objective in such cases.

Material substitution contributes to this objective if any different wastes arising due to particular options implemented are more easily contained in waste management facilities.

Abatement contributes to this objective if abated pollutants are managed appropriately as wastes. The polluting nature of materials abated from causing pollution at source suggests that the objective of containing wastes in disposal facilities is necessary as long as Waste Producers are free to choose abatement options and as long as the objective of maintaining environmental quality standards is to be satisfied.

(4) Maintaining Secure waste streams.

Applying boundary conditions around Waste Producers and Waste Managers (including waste transport operations) suggests that waste options contribute in the following ways.

Waste minimisation by Waste Producers prevents waste arising and so reduces any risk of wastes escaping en-route to disposal facilities.

As with the objective of containing wastes in disposal facilities, the contribution of **material substitution** depends on the particular consequences of any option for wastes arising.

For **abatement** options, the polluting nature of abated waste suggests that they should be well regulated in transit and should be sent to appropriate facilities if waste streams are to be secure.

(5) A market based approach to the polluter pays principle.

All options contribute to this objective as long as none is promoted to the detriment of others.

In terms of the material balancing model, this means making polluters responsible for costs of emitting pollutants to the environment. There is a balance to be struck here between pollution costs appreciated due to emission requirements for individual plants which do not recognise some benefits of waste options and costs appreciated due to measures to maintain regional environmental quality standards which can incorporate broader benefits of options like waste minimisation and some forms of material substitution and broader problems associated with abated pollutants and problem by-products arising from material substitution when they are managed as wastes.

6.3.5 Question L5: What legislative mechanisms encourage other options which contribute to the achievement of environmental goals and objectives in the UK?

The market based approach to the polluter pays principle suggests that options should only be encouraged if they represent the cheapest way to improve environmental performance. The changes to material input and output shown in Table 6.1 for these options may be associated with costs for waste management or recycling services and primary or secondary sources of materials and costs of process change or emission abatement. These costs may be considered as market forces applicable to each option as outlined below.

Waste minimisation can be encouraged by:

Increased costs of raw materials
Increased costs of emissions (the cost of abatement)
Increased costs of waste management
Increased costs of External Recycling
Decreased costs of appropriate process changes

Material substitution can be encouraged by:

Increased costs of scarce materials
Increased costs of polluting materials
Decreased costs of substitute materials
Decreased costs of appropriate process changes (if applicable)
Increased costs of waste management and/or emissions (depending on whether materials are substituted to reduce wastes and/or emissions)

Abatement can be encouraged by:

Decreased costs of waste management (or appropriate recycling) for abated emissions
Decreased costs of abatement technology

6.3.6 Question L6: What are the differences between recycling and other options with respect to:

(a) achievement of the stated goals and objectives of environmental legislation in the UK?

See Table 6.2

(b) legislative mechanisms intended to encourage each kind of response in the UK?

See Table 6.3

The important feature of Tables 6.2 and 6.3 is that due to the market based approach adopted by the UK Government, legislative mechanisms deployed focus on;

making Waste Producers appreciate increased "Emission Costs."
improving standards of waste management generating an increase in "Waste Costs" appreciated by Waste Producers.

(Table 6.3)

These mechanisms tend to promote options that contribute to emission and waste reductions but not those that reduce resource use (Table 6.2). Legislative aspects of Waste Policy formulation and implementation in the UK may be characterised as focussed on waste containment in the waste management sectors and on promoting emission reduction by Waste Producers. Improvements to waste containment indirectly promote waste reduction due to increased costs of waste management.

Table 6.3.2: Differences between Waste Options according to various Promotional Effects of Legislative Mechanisms

CONTRIBUTION OF OPTION	RECYCLING SRM* use	RECYCLING SRM* supply	WASTE MINIMISATION	MATERIAL SUBSTITUTION Scarce for Less	MATERIAL SUBSTITUTION Polluting for Less	ABATEMENT AND WASTE MANAGEMENT
Waste Producing Processes						
Emission Reduction	Only if SRM* is less polluting	Only with abatement	Yes	No	Yes	Yes
Resource Use	Yes	No	Yes	Yes	No	No
Waste Reduction	No	No	Yes	Maybe	Maybe	Waste increase
Waste Management Processes						
Emission Reduction	If recycling is less polluting than usual waste management	If wastes removed are polluting	No	If material becomes waste		Waste facility emissions may increase due to some abated substances
Resource Use	If recycling uses less resources than usual waste management	Yes	Maybe	Maybe		Yes

* Secondary Raw Material

Table 6.3: Differences between Waste Options according to various Promotional Effects of Legislative Mechanisms

PROMOTING EFFECT	RECYCLING		WASTE MINIMISATION	MATERIAL SUBSTITUTION		ABATEMENT AND WASTE MANAGEMENT
	SRM use	SRM supply		Scarce for Less	Polluting for Less	
+ Emission Cost	Only if SRM is less polluting	Only with abatement	Yes	No	Yes	Yes
+ Material Cost	Yes	No	Yes	Yes	No	No
+ Waste Cost	No	Yes	Yes	Maybe	Maybe	Negative effect
- Process Change Cost	If required	If required	Yes	If required	If required	No
- Substitute Material Cost	Yes	No	No	Yes	Yes	No
- Recycling Cost	Yes	Yes	No	No	No	If abated materials are recycled

6.3.7 Question L7: Under what circumstances do differences between recycling and other options matter for the satisfaction of legislative goals and objectives and for responses encouraged by legislative mechanisms used?

Differences between option types matter under circumstances where legislative mechanisms fail to promote complementary development of the four options in the context of achieving legislative goals and objectives. Of the set of potential mechanisms identified in Table 6.3 the following can be considered as applicable to the UK approach:

Increased Emission Cost - Requirements to reduce and monitor emissions raises the cost of operations which emit pollutants. The cost of abatement and waste management can be considered as a default value for this cost increase. This cost increase promotes abatement, waste minimisation and some forms of material substitution and recycling (those where replacement materials are less polluting or where secondary materials are recycled abated emissions).

Increased Waste Cost - Requirements to improve waste management facilities are costly. These costs are ultimately borne by the users of waste management facilities who appreciate increased waste costs. This mechanism encourages recycling, waste minimisation and forms of material substitution that reduce waste volumes (especially the more costly kinds of waste). This mechanism also discourages abatement.

The mechanisms identified do seem to promote options which are identified in Table 6.2 as contributing to legislative goals of environmental conservation but not always those which may contribute to reduced resource use. UK environmental legislation can be considered in this light as focussed on environmental conservation but not on resource conservation. In this sense, "sustainable development" is not a goal of UK legislation. This has consequences for recycling since resource use benefits of recycling are not recognised by Legislative Agencies in the UK and consequentially recycling is not promoted as much as it would be if regulatory tools deployed in the UK promoted reductions in resource use.

Regarding lower level objectives, and mechanisms for promoting change there are some discrepancies. For example, abatement, which contributes to reducing pollution at source does not necessarily contribute to maintaining environmental quality standards since abated emissions may contribute to pollution from waste management processes. Although some measures to reduce pollution from waste facilities have increased costs of waste management, there is no accounting for whatever emissions do arise in assessment of pollution for firms which produce the waste.

Increases in waste costs appreciated by Waste Producers are due to improvements in practice but they do not include any representation of social costs arising from even the best managed waste facilities.

Current regulation to limit pollution at source considers emissions from industrial plant into all environmental media except via the waste stream. Similarly, the process concerned is considered independently of any material supply processes which may cause pollution. This "ring fencing" of industrial plant limits the ability of regulation to account for broader environmental consequences of industrial activity.

Local and Regional environmental quality standards can be regulated by limiting the number of industrial plants licensed to operate in a given area but not by restricting emissions from any plant below levels determined nationally for similar processes according to BATNEEC or BPEO principles.

Regarding market mechanisms, the assumption that firms simply respond to market forces to favour options as shown in Table 6.3 is simplistic. In the context of the overall model represented in Fig 3.4, implementation of options should also be considered as influenced by the internal policy of firms. In Section 6.4, the material balancing model is used to represent some of the issues identified in Chapter Five enabling a more detailed analysis of how market forces influence the implementation of options by Waste Producers.

6.4 Applying the Material Balancing Model From The Waste Producer Perspective

This section addresses the technical linkages of Fig 3.5 (p.115) to and from the three Waste Producer boxes (related to questions P1 through to P7).

In this context, appropriate boundary conditions for the material balancing model include time horizons, control of material stream processes and control of any enabling or debilitating operations which may affect costs and benefits associated with changes envisaged. Eg. ownership of an equipment supplier may enable access to lower priced abatement technology.

For Waste Producers controlling a given bounded process, the material balancing model focuses on material inputs, product outputs, emission output and waste output. The process itself and factors controlling inputs and outputs remain as a "black box". For industrial organisations, a set of attributes may be postulated as an approximate model of this black box.

Environmental consultants mentioned different mechanisms deployed by firms implementing different option types (Section 5.4). The following set of attributes summarises some of these findings.

1. Interactions with suppliers

1a. Interactions with Suppliers of materials

This attribute represents an organisation's ability to change material inputs.

This attribute is useful for options which influence material balance by changing material input (A in Fig 6.1).

1b. Interactions with Technology Suppliers

This attribute represents an organisation's ability to import technology to apply to existing plant or even to import skills necessary to modify existing plant instead of relying on internal skills.

This attribute is useful for options which influence material balance by changing process technology (B in Fig 6.1) or abating emissions through retrofitting of technology at the end of pipe.

1c. Interactions with Waste Hauliers and Waste Managers

This attribute represents an organisation's ability to change waste management services employed.

This attribute is useful for any change to material balancing which entails waste output change (E in Fig 6.1).

2. Interactions With Customers

This attribute represents an organisations ability to market product changes and recognise relevant changes in demand for products.

This attribute is useful for options which influence material balance by changing product output (D in Fig 6.1).

3. Interactions with Regulators

This attribute represents an organisation's ability to recognise the demands of regulatory authorities and to have regulatory authorities recognise changes adopted as contributing to satisfaction of legislative requirements.

This attribute is useful for options which influence material balance by changing regulated outputs. Preliminary research (Chapter Four) suggests that emission and waste outputs (C and E in Fig 6.1) are regulated.

4. Internal Skills Base:

This attribute represents an organisation's ability to change the process it controls.

This attribute is useful for options which influence material balance by changing process technology (B in Fig 6.1).

Key to Fig's 6.2 to 6.5

Material inputs and outputs

A - Material input including;

a1 - Primary materials and/or
a2 - Secondary material

B - The production process managed by Waste Producers

C- Emission output

D - Product output to;

d1 - End use (consumers)
d2 - Primary process (another industrial firm)
d3 - Recycle

E - Waste Output

Attributes of Waste Producers

Attributes of Waste Producer firms which control inputs and outputs are represented as capabilities to perform certain kinds of interaction or to deploy appropriate internal skills.

1 - Interactions with Suppliers, including;

1a - Material Suppliers
1b - Technology Suppliers
1c - Waste Hauliers and Managers

2 - Interactions with Customers

3 - Interactions with Regulators

4 - Internal Skills

Interactions of Attributes

Control attributes are deployed in different combinations to implement different option types. Each combination involves a set of attributes interacting with each other as well as external agencies.

Dotted lines - represent simple interactions eg. changing the quantity of an order.

Solid lines - represent more complicated interactions eg. changing Suppliers.

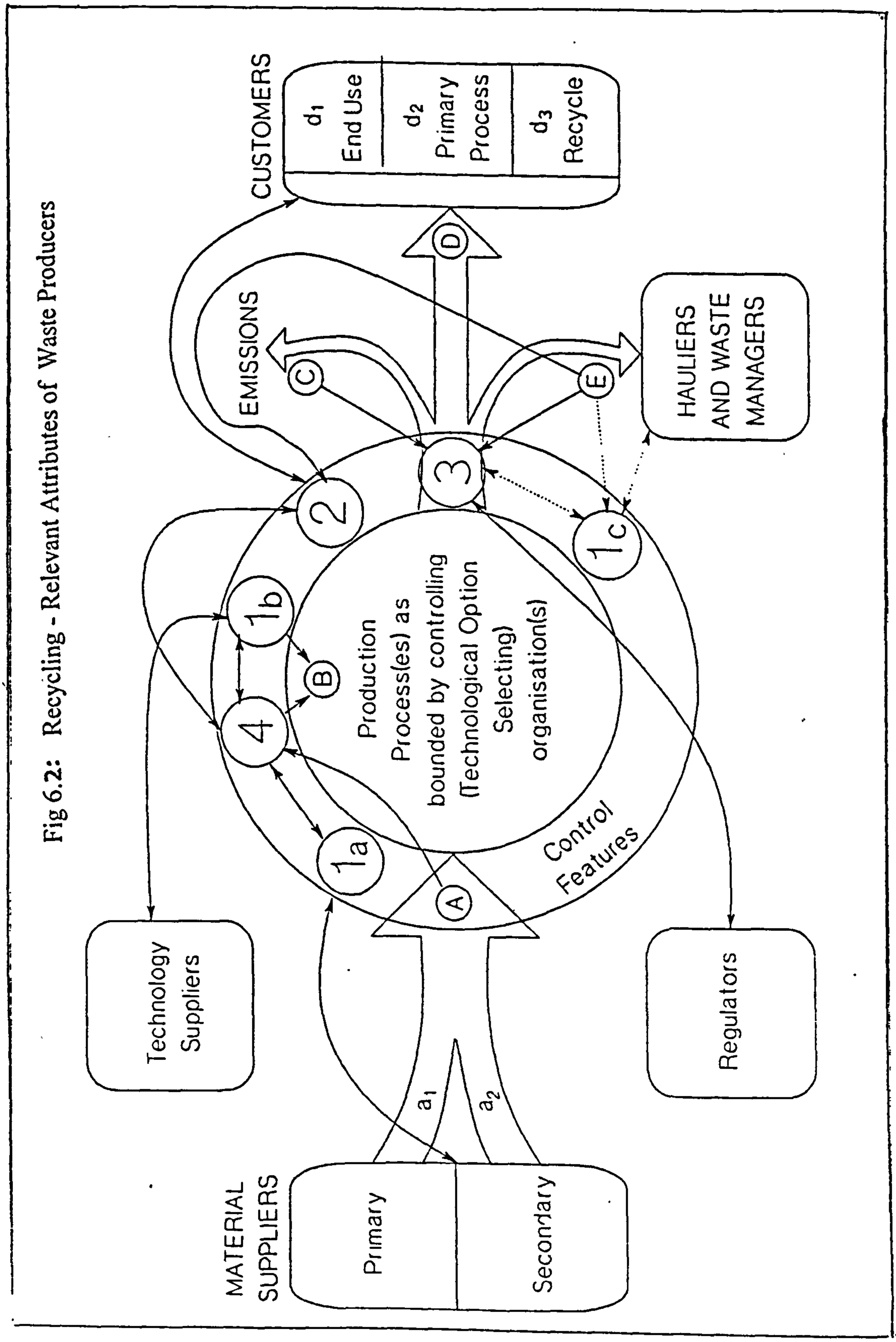


Fig 6.2: Recycling - Relevant Attributes of Waste Producers

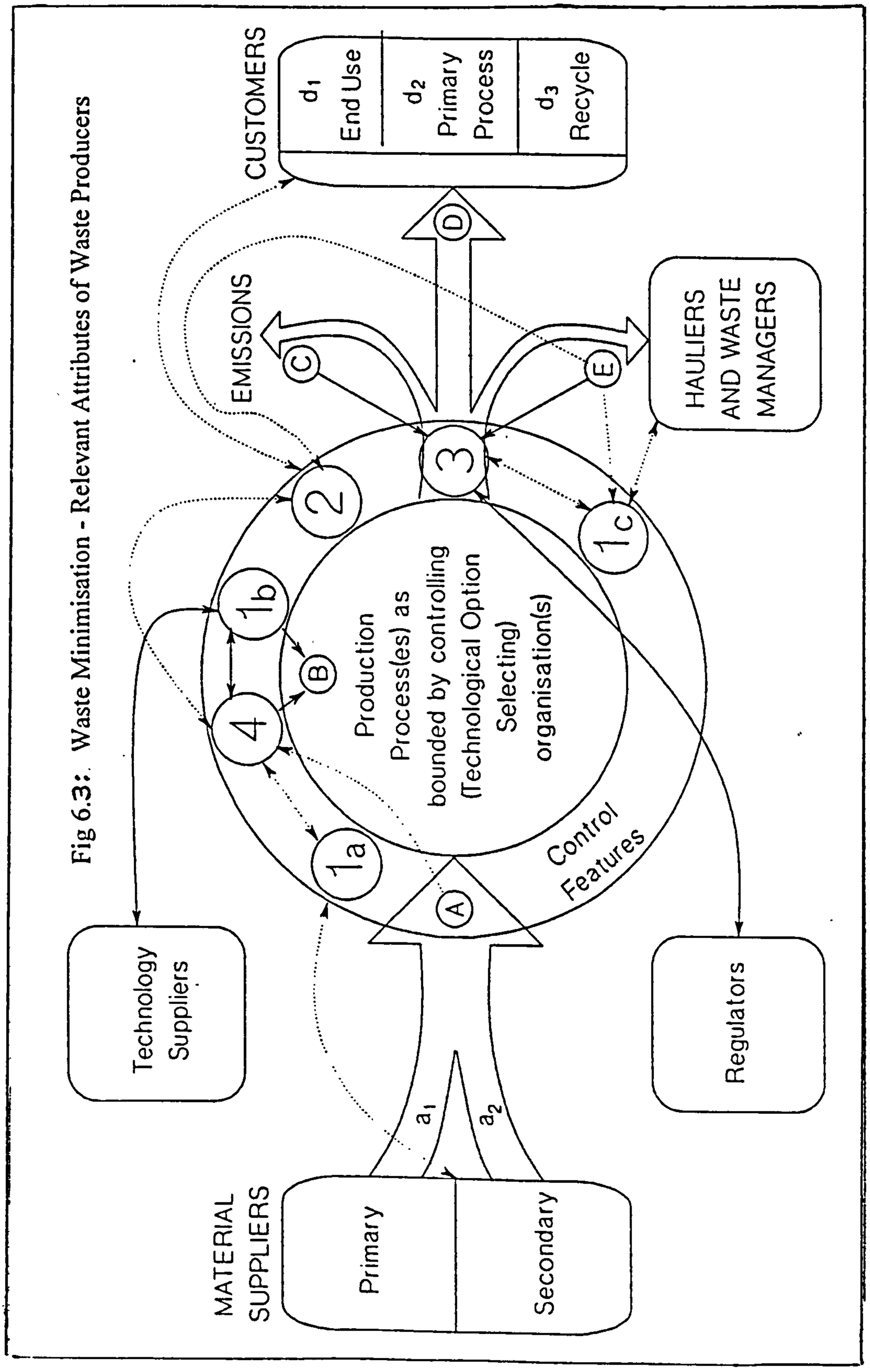


Fig 6.3: Waste Minimisation - Relevant Attributes of Waste Producers

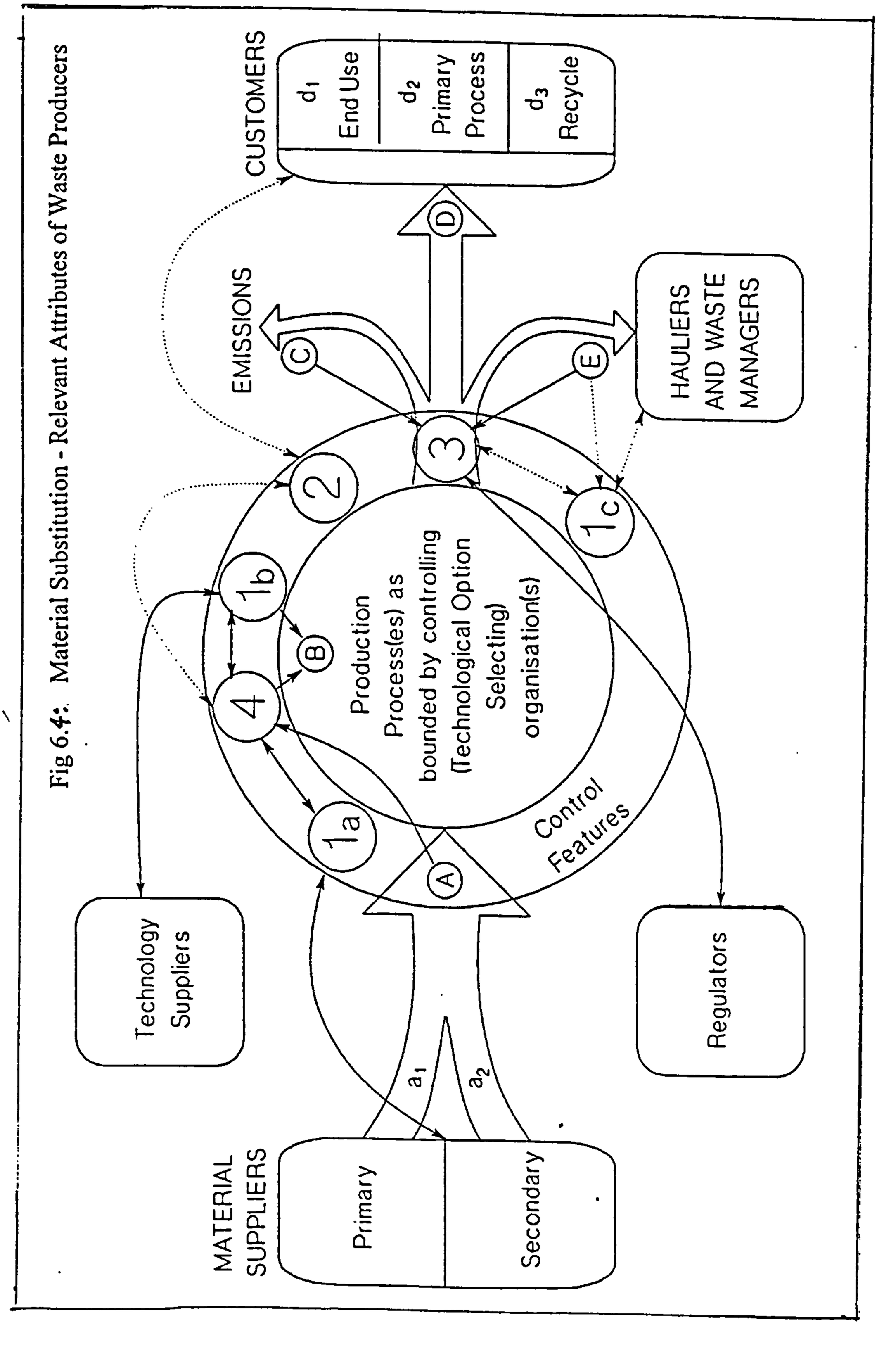


Fig 6.4: Material Substitution - Relevant Attributes of Waste Producers

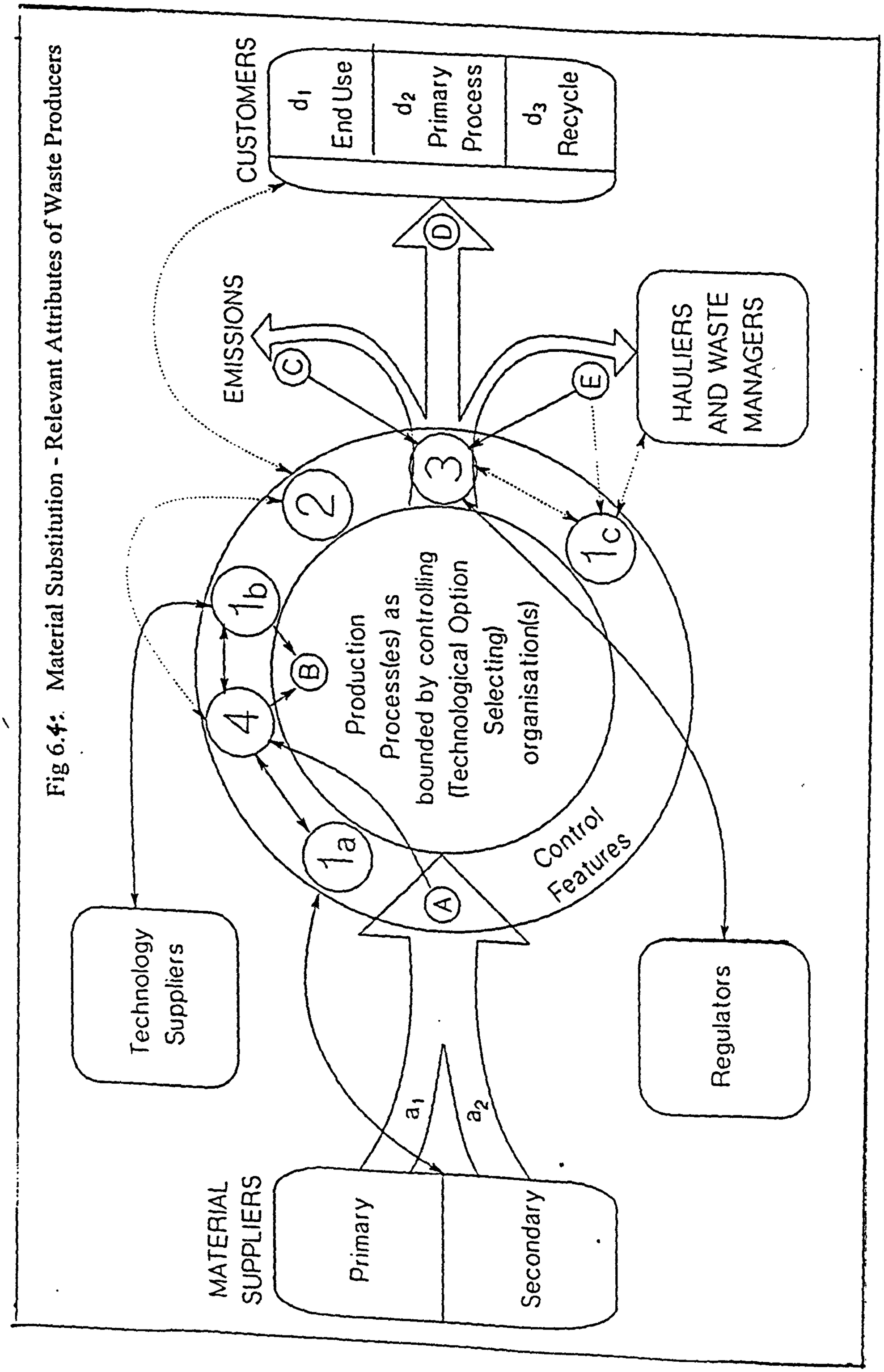


Fig 6.4: Material Substitution - Relevant Attributes of Waste Producers

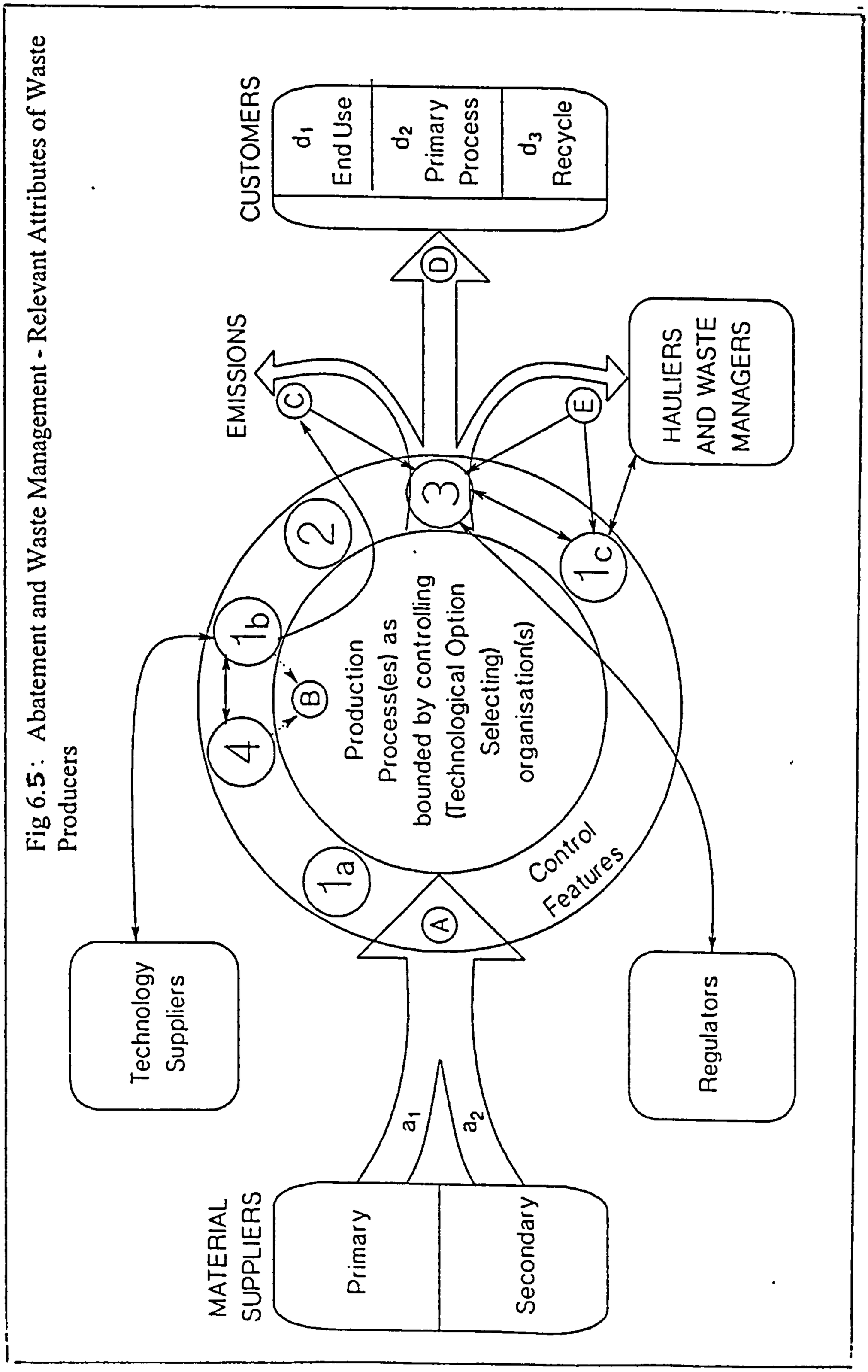


Fig 6.5: Abatement and Waste Management - Relevant Attributes of Waste Producers

Each attribute is associated with changes of material inputs or outputs or with changes to process technology. This enables the model represented in Fig 6.1 to incorporate these elements as control features. This is shown in Fig's 6.2 through 6.5. Solid lines represent control factors incorporating new information as part of the process of change (eg. finding a qualitatively different waste management service). Dotted lines represent control factors governing changes along established themes (eg. quantitative changes to order books for established waste management services).

These attributes contribute to the general modelling exercise in two ways;

i) Attributes represent an organisations "receptivity" to particular changes in external environments such as increases in waste management prices.

ii) Attributes represent an organisation's "access" to new materials, processing techniques, waste management services or regulatory advice.

The above attributes are relevant to the research questions in two ways:

i) For Questions P2 and P4, perceived contributions of different waste options depends on organisational receptivity to information about changes to external costs and benefits appreciated by external agencies which may be represented in prices for alternative goods or services or in new emission standards imposed by regulators.

ii) For Questions P3 and P5, ability to implement options depends on organisational access to skills, goods, services and regulatory recognition.

This model and the findings of research presented in Chapter Five are considered below in the context of the Waste Producer questions posed in Sections 3.2.

6.4.1 Question P1: What are the goals and objectives of industrial Waste Producers to which recycling could contribute?

From research presented in Section 5.3, it is apparent that cost and environmental improvement are key considerations for firms considering waste options. However, firms do not seek to maximise some function of cost and environmental improvement. Several rationals were identified according to which firms seek to "achieve environmental improvement at lowest cost" as a means of contributing to the firms profitability. Whether "lowest cost" is a simple financial comparison or whether it includes judgement of more qualitative costs (such as damage to a firm's image) depends on a particular firm's situation and outlook. The amount of environmental improvement sought and the way in which cost is assessed depends on the firm's rationale. Four kinds of rationale are presented in Fig 5.1 (shown below for easy reference). These rationales are findings of research rather than consequences of applying the material balancing model.

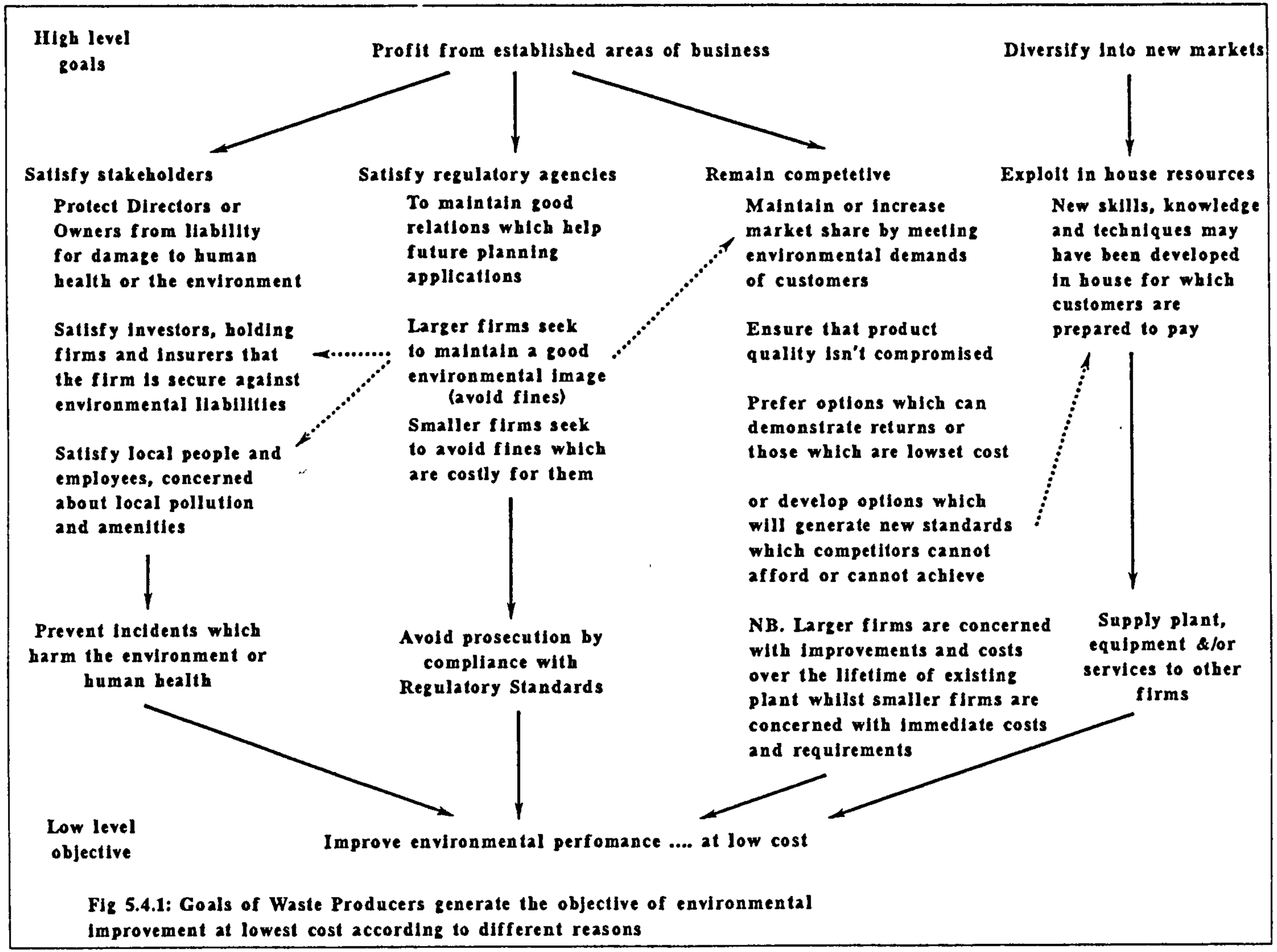


Fig 5.4.1: Goals of Waste Producers generate the objective of environmental improvement at lowest cost according to different reasons

Question P2: What benefits of recycling industrial wastes are recognised by Waste Producers as contributory to achievement of their goals and objectives?

For supply of secondary materials, the contribution to profit is:

C(W1) - C(R) - C(W2) - C(P)

where;

C(W1) = the established cost of waste removal

C(R) = the cost of removal of secondary materials

C(W2) = the cost of removal of any residual wastes

C(P) = the cost of any changes required to the production process

For use of secondary materials the contribution to profit is;

C(M1) - C(M2) +/- R(S) - C(P)

where;

C(M1) = the cost of replaced materials

C(M2) = the cost of secondary materials used

R(S) = increase or decrease in revenue from product sales

C(P) the cost of any changes required to the production process

6.4.3 Question P3: What organisational mechanisms are deployed to implement recycling of industrial waste by Waste Producers?

For supply of secondary materials, some fraction of wastes must be removed to recycling destinations requiring interaction with Waste Hauliers and Waste Managers. An internal skills base may be exploited if process change is required. This may involve substantial changes to production processes or simply changes to waste handling practices and provision of additional waste containers for separated wastes.

For use of secondary materials, some fraction of raw materials must be replaced with secondary materials. Interactions with material suppliers are exploited. Also interactions with customers may be required to market changes to final products. These interactions are shown in Fig 6.2 (p.134).

6.4.4 Question P4: What benefits of other industrial options are recognised by Waste Producers as contributory to achievement of their goals and objectives?

Waste minimisation - the contribution to profit is;

C(E) + C(W) + C(M) - C(P)

where;

C(E) = the cost of emissions avoided

C(W) = the cost of waste no longer produced

C(M) = the cost of materials not used

C(P) = the cost of changes to the process

Material Substitution - the contribution to profit is;

C(E) + C(W1) - C(W2) + C(M1) - C(M2) +/- R(S) - C(P)

where

C(E) = the cost of emissions avoided

C(W1) = the cost of waste no longer produced

C(W2) = the cost of any new waste produced

C(M1) = the cost of materials replaced

C(M2) = the cost of materials substituted

R(S) = any increase or decrease in revenue from product sales

C(P) = the cost of any changes required to the production process

Abatement coupled with Waste Management - contribution to profit is;

C(E) - C(M) - C(T)

where;

C(E) = the cost of emissions avoided

C(M) = the increased cost of waste management (due to abated emissions)

C(T) = the cost of abatement technology

6.4.5 Question P5: What organisational mechanisms are deployed to implement other options?

Waste Minimisation requires change to process technology. Interactions with process technology suppliers and/or internal skills may be exploited, as shown in Fig 6.3 (p.135).

Material Substitution requires change to material input and possible change to process technology. Interactions with material suppliers are exploited. Also interactions with customers may enable marketing of changes to final products, as shown in Fig 6.4 (p.136).

Abatement requires containment of emissions and their removal to appropriate **waste management** destinations. Interactions with abatement technology suppliers and interactions with waste managers are exploited as shown in Fig 6.5 (p.137).

6.4.6 Question P6: What are the differences between recycling and other options with respect to:

(a) achievement of stated environmental goals and objectives of Waste Producers?

See Table 6.4

(b) attributes employed to implement each kind of response by Waste Producers?

See Table 6.5

Tables 6.4 and 6.5 summarise differences identified by applying the material balancing model in the preceding sections. The important feature to note is that although abatement options are easier to implement they may have a negative contribution to profit due to rising waste costs for abated materials. Although waste minimisation options contribute to profit under most circumstances they can require deployment of internal skills or purchase of technology which, for waste minimisation options can be expensive (since plant may need to be closed or replaced). Recycling options may not involve such radical changes to processes, but they do involve interaction with Waste Hauliers and Waste Managers to identify appropriate sources of or destinations for, recyclable materials. Recycling then is highly dependent on whether appropriate facilities for recycling wastes are developed.

Table 6.4: Differences between Waste Options according to Contributions made to Waste Producer Profit Goal due to Costs Appreciated

CONTRIBUTION OF OPTION Due to High (+) or Low (-) Costs	RECYCLING SRM use	RECYCLING SRM supply	WASTE MINIMISATION	MATERIAL SUBSTITUTION Scarce for Less	MATERIAL SUBSTITUTION Polluting for Less	ABATEMENT AND WASTE MANAGEMENT
+ Emission Cost	Only if SRM is less polluting	Only with abatement	Yes	No	Yes	Yes
+ Material Cost	Yes	No	Yes	Yes	Yes	No
+ Waste Removal	No	Yes	Yes	Depends on effects of material subst'n on wastes arising		Negative effect
- Process Change Cost	If required	If required	Yes	If required	If required	No
- Substitute Material Cost	Yes	No	No	Yes	Yes	No
- SRM Removal Cost	No	Yes	No	No	No	If abated materials are recycled
+/- Value to Product	Positive or negative effect		Maybe	Positive or negative effect		No
- Abatement Cost	No	No	No	No	No	May be default emission cost

Table 6.5: Differences between Waste Options according to Waste Producer Attributes Employed to Implement each Option Type

ATTRIBUTES EMPLOYED	RECYCLING		WASTE MINIMISATION	MATERIAL SUBSTITUTION		ABATEMENT AND WASTE MANAGEMENT
	SRM use	SRM supply		Scarce for Less	Polluting for Less	
Relations With:						
Material Suppliers	Yes	No	Only to reduce orders	Yes	Yes	No
Technology Suppliers	If process change is required and internal skills are not appropriate		If internal skills are not approp'te	If process change is required and internal skills are not appropriate		Yes
Waste Hauliers and Managers	No	Yes	To reduce orders	Only if wastes are affected		Yes
Customers	If recycling affects product		Maybe	If product value is affected		No
Regulators:						
Emissions	No	No	Yes	No	Yes	Yes
Waste	No	Yes	Yes	Only if waste stream is affected		No
Internal Skills	If process change is needed		Yes	If process change is needed		No

6.4.7 Question P7: Under what circumstances do differences between recycling and other options matter to Waste Producers for the satisfaction of environmental goals and objectives and for implementation of responses?

Differences between options matter because firms differ in more ways than simply the categories of process they operate. Firms operating identical processes may implement different options. Some important differences between firms identified in Section 5.4 include:

A firm's size

Smaller firms do not have access to the kinds of resources appropriate to implementing waste minimisation options (internal skills and/or capital to purchase plant) and may not have the purchasing power to convince material suppliers to customise alternative materials for them. Such firms may be limited to abatement or recycling options.

Whether a firm operates existing plant or intends to open new plant

Options requiring process change are easier to implement when opening new plant (or during plant refurbishment). Furthermore, regulatory requirements are more strictly enforced for new plant.

Existing plant may be adapted without refurbishment by employing abatement options if suitable waste management options are identifiable (this may include recycling).

Whether a firm seeks to push environmental standards in its sector

Some firms may be well positioned to improve standards (if they are opening new plant for example) and may seek to do so if they are confident that competitors will have to follow suit.

Other firms may simply adopt minimum changes required by implementing the latest abatement techniques.

Whether the firm seeks to diversify into environmental markets

Opportunities to export technology or skills developed during environmental improvement may justify implementation of costly alternatives such as waste minimisation.

The strictness of regulations imposed in the sector a firm operates in

Firms operating in sectors dealing with the most polluting and hazardous materials are more likely to be required to reduce pollution radically and may not be able to identify waste disposal options for abated pollutants.

The local area a firm operates in

The strictness of regulations imposed by a firm's Local Authority can be dependent on how the Local Authority balances environmental issues and other local issues such as employment. Large local employers may be able to implement less costly options in some areas.

6.5 Conclusions

The material balancing model is useful for representing some of the findings of research presented in Chapters Four and Five. This model does not of itself identify objectives relevant to Waste Policy formulation or identify all conditions which influence implementation of Waste Policy. However the material balancing model does serve three useful purposes;

Legislative Objectives can be considered in terms of boundary conditions to use for material balancing and the contributions of different option types can be identified for each objective (Sections 6.3.2 and 6.3.4).

Costs and benefits appreciated by Waste Producers can be associated with material inputs and outputs and changes to processes associated with each option type (Sections 6.4.2 and 6.4.4).

Attributes of waste producing firms can be identified which are pertinent to implementation of waste options (Sections 6.4.3 and 6.4.5).

Differences between waste options are identifiable in terms of relevant characteristics derived from application of the material balancing model (Sections 6.3.6 and 6.4.6). These differences are shown to matter (Sections 6.3.7 and 6.4.7) due to conditions identified in Phase One of the research (Chapters Four and Five). One key issue identified by combined consideration of Legislative and Waste Producer perspectives is outlined below.

Key Issue

The market based approach to the polluter pays principle assumes that firms can select waste options which are best suited to their needs and which satisfy regulatory requirements. This is supported by provision of information in HMIP guidance notes and subsidy for environmental consultancy but not by subsidy of any particular option type.

Some firms are able to consider all options from the fortunate position of having good resources (skills appropriate for implementing options and capital). This applies particularly to larger firms and firms developing new plant or reconditioning existing plant. However, not all firms are in similarly fortunate circumstances and some firms are limited to implementing options which involve less investment and/or less change to processes.

Well resourced firms implementing change at appropriate times are able to consider benefits such as improved competitiveness due to pushing

environmental standards in their sector (since competitors will have to match or improve on new standards developed). Such firms may tend to focus on internally justified options like waste minimisation rather than exploiting opportunities to develop recycling options which involve external agencies (and may be of benefit to competitors). The internal focus of such firms may be encouraged by emission requirements that "ring fence" production processes and do not recognise some of the broader benefits of recycling (as well as waste minimisation and some forms of material substitution).

Consequently less well positioned firms are unable to exploit recycling options due to a shortage of new recycling infrastructure developed to improve environmental performance of industry. Smaller firms and firms operating existing plant may be limited to implementing abatement options and material substitution options which require relatively minor changes to plant and little capital investment. However such options can result in increased running costs due to high prices charged by Waste Managers and suppliers of recently developed substitute materials.

The issue then is that recycling may not be promoted to the same degree as other options because waste producing firms that can afford to and are able to develop such infrastructure do not need to whilst waste producing firms that need access to such infrastructure cannot afford to or are not able to develop it themselves.

Other Issues

Some benefits of recycling are appreciable in terms of maintaining environmental quality standards but not in terms of limiting pollution at source from the Legislative Perspective. However, there is little evidence that regulatory mechanisms represent broader benefits of recycling in terms appreciated by Waste Producers (some Local Authorities insist on involvement in recycling schemes but such insistence is contrary to the market based approach to the polluter pays principle and can be legally challenged).

Variations between Local Authority interpretations of environmental legislation and consideration of other local issues by Local Authorities can generate geographically diverse regulatory requirements. This may be a benefit to firms poorly positioned to implement the most progressive kinds of improvement if they operate in the right area. Existence of less strictly regulated competitors may reduce confidence of progressive firms in rationales that are justified by continued feedback of improvements achieved into new standards of regulation.

Considering material balancing within national boundary conditions suggests that the full benefits of recycling, waste minimisation and forms material substitution which improve resource use, are only accounted for if pollution arising at all stages of a material stream (from extraction or import to disposal or export) is recognised by regulatory mechanisms employed by Legislative Agencies to somehow make Waste Producers appreciate costs associated with pollution arising from industrial operations upstream and downstream of the process regulated. The legislative objectives of "containing wastes in disposal facilities" and "ensuring secure waste streams", whilst they are effective forms of improving waste management standards, they do not enable account to be taken of downstream pollution during regulation of Waste Producers. Similarly the

focus of Legislative Policy in the UK on ring fenced regulation of industrial processes to "limit pollution at source" does not account for pollution and environmental degradation arising from resource extraction. Where materials are imported and products exported, benefits of recycling and other options similar in this respect are not appreciated in environmental terms at the national level. However, reduced use of imported resources per unit of product exported does represent a benefit in terms of balance of trade.

Some firms do employ product life cycle analysis which considers environmental impact from "cradle to grave." Such an aproach may be promoted in the EU if ecolabelling is introduced to consider the materials used in products, their sources and there final treatment as wastes.

The "key issue" is outlined above in considerable detail since it is the issue most relevant to the interests of BCWM and is the issue explored in the case study conducted in Phase Two of the research (presented in Chapters Seven through Nine). The "other issues" are presented here as some issues which are identified in this research which could be explored by future research. Some findings of the Phase Two research do address these issues and such findings are considered in the context of these issues below. In Chapter Ten, the findings pertinent to the key issue are discussed and some consideration of other issues is also included.

The case study considers the option for BCWM to recycle construction wastes at landfill sites. As a Waste Manager, BCWM experiences different conditions of regulation than those appreciated by Waste Producers. Whilst recycling plant licensed as a material processing operation must satisfy emission standards applicable to other similar processes, if the plant is licensed as a waste management process (as it would be if installed at a landfill site) it only has to be shown that BCWM are "fit and proper persons" to manage such an operation. Furthermore, the remit of WRA's is strongly focused on preparing regional plans for waste disposal, hence benefits in terms of reduced pollution from waste management operations due to recycling some waste may be appreciated by BCWM in terms of improved likelihood of receiving planning consents for landfill sites that incorporate recycling options.

In Chapter Seven, particular issues faced by a construction firm are explored and findings are interpreted in terms of the consequences in this particular case for Waste Managers and in particular for the viability of the recycling option.

CHAPTER SEVEN

Waste Policy Formulation and Implementation by a Firm in the Construction Sector

7.1 Introduction

The modelling activity presented in Chapter Six highlights general issues of Waste Policy formulation and implementation. However, the modelling devices and conditions presented are based on information which focuses on general waste issues faced by Waste Producers and Legislative Agencies. Although general objectives are presented, the modelling devices and conditions cannot be applied to determine whether a particular option to recycle waste is viable. The modelling tools and conditions presented do however demonstrate the kind of information required to make such a determination.

The case of recycling construction waste was identified as an option of interest to Blue Circle Waste Management Ltd (BCWM) and as a researchable option appropriate for a case study to show how issues and conditions identified by the modelling activity occur in the real world to influence the viability of recycling options.

Research presented in this chapter serves two purposes. Firstly, investigation of waste issues within a construction firm supports the modelling activity presented in Section 6.4 by showing how issues faced by one particular Waste Producer relate to the kinds of issue identified in Sections 6.4 and 6.5. Secondly, this research provides qualitative information about waste production in the construction sector which is relevant to viability of recycling construction waste for BCWM. This information suggests that changes to wastes arising from construction activities are likely to include:

Reduction in volume due to waste minimisation

Separation of packaging materials (and other compressibles) at some construction sites. Note that the packaging chain's Producer Responsibility Group has nearly completed plans to recycle 58% of packaging waste by the year 2000 in response to government pressure (ENDS July 1994 p.14-15). Implementation of such a plan would be likely to require considerable levels of source separation for packaging waste.

Some separation of hazardous materials on well managed construction sites although waste skips will continue to contain a small fraction of noxious materials

This information is used in Chapter Nine to provide a rationale for modelling the potential benefits of recycling construction wastes at a landfill site.

Information about waste issues faced by a large design and build firm was elicited in interviews conducted at the firm's central office. As with the consultant interviews presented in Chapter Five, the interviews conducted were informal. In this case, however, the interviewees performed different roles in the firm. Information was sought on the basis of the roles of interviewees in the

firm. For example, legislative questions were addressed to one of the firm's legal advisers.

The firm's Quality Manager had performed waste audits within the firm and was able to outline issues relevant to wastes faced by the firm. Interviews with other staff focussed on confirming the information elicited from the Quality Manager and expanding this information by addressing topics raised by the Quality Manager and relevant to the particular roles of respondents.

7.2 Interview Method

Initial contact was established with one of the company's quality management team following recommendation's of Respondents 20 and 21 from the review of consultants (Chapter Five). These consultants had both helped the Quality Manager prepare waste audits within the firm. The Quality Manager was contacted by telephone and he offered to arrange a series of meetings with employees from different departments within the firm. The meetings were conducted at the firm's head office over the course of a day in September 1992.

As with the consultant interviews (Chapter Five), the interviews were conducted informally as conversations. Rough notes were taken during interviews and written up afterwards. Copies of memoranda and a letter were also supplied.

Prior to the meetings, a fax was sent to the Quality Manager which confirmed the initial meeting day and time. The fax also presented the following set of questions which the meeting was to address:

1 What forces for and barriers to change have influenced environmental performance of the company?

2 What current practices influence waste arising ?

3 What legislative pressures influence the company's waste policy?

4 What technological options are known of and how are they assessed?

5 What weightings other than financial costs and benefits (if any) are given to environmentally pro-active options?

6 What problem wastes are identified by the company, why do they pose a problem and what is done to alleviate problems?.

These questions seemed appropriate to focus the interview on issues identified in Chapter Six associated with Waste Policy formulation and implementation by Waste Producers. The role of each question is discussed along with responses given and interpretations offered in Section 7.4.

Presenting these questions in advance enabled the Quality Manager to prepare a presentation of relevant information. This presentation and the discussion which followed (involving the researcher and the Quality Manager) lasted for two hours. Subsequent interviews with other staff at the firm focussed on

addressing topics which the Quality Manager recommended for their attention and on following up issues raised by the Quality Manager which involved other departments within the firm.

7.3 Background Information

This information is based on the Quality Managers initial remarks and on information presented in the firm's annual report.

The surveyed company's main business comes from design and build contracts. The firm is primarily involved with contracts for large buildings including; supermarkets, office blocks, warehouses and blocks of flats. The firm has subsidiary interests in materials supply and haulage (for materials supply only).

The firm employs between two and five hundred full time staff and up to ten times this number at any time are also employed on a contract basis. The firm is usually directly involved in construction operations on between ten and thirty different sites at any time.

The company has a strong focus on quality and efficiency and expects to emerge from the recession in a good position to "take up slack" in UK and European construction markets. The Quality Manager referred to the company as one of the most professional in the business.

The company is strategically positioned to exploit opportunities arising from higher standards and raised customer expectations. For example it is one of the first of its kind registered for BS: 5750 (quality management) and expects to be the first to acquire BS: 7750 (environmental management) accreditation. Such standards are perceived as helpful for marketing the company as "professional."

This company provides a good example in the context of this research because:

Involvement in design and build yields a good appreciation of issues across the sector.

The company is forward looking and has researched and implemented techniques intended to contribute to setting standards for professional construction.

The company has one central office enabling contact with staff from various departments.

7.4 Research Findings and Interpretation

The timetable of interviews conducted over the day was as follows:

10.00 - 12.00 Presentation by a Quality Manager followed by discussion

12.00 - 1.00 Meeting with a buyer and site manager

1.00 - 2.00 Lunch with the Quality Manager

2.00 - 3.00 Meeting with a legal adviser

3.00 - 3.30 Photocopies taken of documentation received

The Quality Manager began his presentation by describing the company and the kind of work it is involved with (see Section 7.3). He went on to describe his own role in the firm which may be summarised as:

> Leader of a waste auditing project within the firm which lasted for one and a half years and which is now occasionally reviewed
>
> Involvement in other projects led by other members of the quality management department
>
> Liaising with site managers and buyers to ensure that materials supplied are of sufficient quality and in the correct amount for construction projects undertaken by the firm

The Quality Manager then went on to address each question in turn. The content of this presentation and the discussion which followed are summarised below.

7.4.1 Question 1: What forces for and barriers to change have influenced environmental performance of the company?

This question is used to elicit information regarding general environmental issues faced by construction firms and conditions which have influenced this firm's resolution of those issues. In terms of the conceptual model, this question is used to identify which of the rationales presented in Section 6.4.1 are applicable to this firm. Prior knowledge of other potential rationales enables consideration of conditions which could apply to other construction firms, such as smaller building firms.

In terms of information pertinent to the case study and BCWM's interests in recycling, conditions faced by construction firms contributes to determining the kinds of waste they produce. These conditions are relevant to a general understanding of likely changes to construction waste streams which may influence the viability of recycling construction waste.

The Quality Manager responded to this question by outlining the following forces and barriers faced by the firm.

FORCES

i) Existence of a wealthy market niche consisting mainly of; large supermarket chains, businesses seeking to relocate to rural or greenbelt sites and the Canary Wharf development.

Cash rich customers in these areas want buildings which are; durable, efficient (low heating and maintenance costs) and which do not encourage public complaint (which can jeopardise future planning consents). This niche is expected to grow with national economic recovery from recession.

In terms of rationales, this response reflects a desire to remain competitive by satisfying customer requirements. These requirements are associated with efficiency of buildings (contributory to customer profits) and with a need to "satisfy local people and employees, concerned about local pollution and amenities" which is contributory to customer profits in that it contributes to "satisfying stakeholders." These rationales are identified in Fig 5.1 (p.139). The construction firm itself responds to conditions appropriate to environmental rationales of customer firms.

ii) Popularisation of the BS: 5750 (quality management) scheme which supports claims of quality in final products and materials used. Acquisition of BS: 5750 is seen as necessary for construction firms which pursue contracts at the top end of the market. This scheme supports claims regarding low maintenance and heating costs for buildings which often rely on ensuring that materials used are supplied as specified by the designers.

This response also reflects the importance of meeting environmental demands of customers for this firm. In this case there is also some suggestion that the firms seeking construction contracts at the top end of the market are achieving some degree of "sectoral standardisation" which can reinforce environmental expectations of customers.

iii) A trend towards more stringent enforcement of standards for buildings and building sites by Local Authorities. Standards for buildings include requirements for natural lighting, ventilation, and structural integrity. Standards for building sites include safety requirements (such as fencing), noise level limitations, restrictions on vehicle traffic entering and leaving sites and measures required to reduce dust. Although the firm usually operates to better standards than those required, these standards prevent competing firms from blatantly operating to low standards and offering radically lower quotes for contracts.

This response reflects a need to "satisfy regulatory agencies." In this case though, regulators seem to be more concerned about safety requirements and local amenity issues and the final quality of the product than in controlling waste during the construction process. One exception is the requirement to reduce dust. It seems that regulatory conditions in the construction sector do not directly address waste and pollution issues (other than dust). Note though, that requirements arising from safety and amenity issues do have an indirect effect on waste practices as is outlined in Section 7.4.3. Also the Duty of Care now places an obligation on firms to prevent contamination of waste streams.

iv) Reducing waste is a way to cut costs without necessarily reducing quality of products. This has been emphasised by recent increases in unit costs for waste management (ie the price per skip taken away). The firm sub-contracts waste removal to haulage firms on the basis of lowest price offered per skip removed. Hauliers do not usually charge a rental fee for the skips.

This response emphasises the firms focus on quality of final products and introduces a financial imperative which reflects the profit goal of most waste producing firms.

BARRIERS

i) The construction sector continues to include more traditional and even "cowboy" operators whose lax standards act as barriers to change (or even as forces for regressive change) in more price sensitive sectors. These firms tend to be restricted to operating in areas where Local Authorities are lax in imposing regulations.

This response emphasises the firms own situation as progressive in terms of meeting regulatory standards. This response also shows that not all construction firms employ similar rationales. To assume that there is only a top end and a bottom in construction markets with nothing in between is simplistic. However, such a distinction does highlight one alternative to be considered.

Identifying lax firms as limited to operating in a few geographic areas suggests that they are relatively small firms. That *some* small firms can offer cheaper products to customers more concerned about price than quality highlights the issue that regulatory standards are not universally stringent. Indeed, the British Standard scheme mentioned above involves voluntary commitments only by construction firms.

The issue here is analogous to the issue of firms seeking to improve environmental performance amidst uncertainty about whether competitors will be forced by regulators to follow suit (p.147). In this case however, the issue concerns product quality rather than the process of construction. The firm seeks some comfort in the fact that sufficient customers do seek quality products and seek out more professional construction firms. Extending this analogy to environmental regulation of industry suggests that in some sectors, consumer led improvement can play a significant role but that without ongoing tightening of regulation (in all local areas) then opportunities may remain to be exploited by firms focusing on price reduction at the expense of environmental performance.

ii) Some competitors offer prefabricated buildings which are cheap and easy to build but which are fairly ugly. If a customer is looking for a cheap building which will last for only ten years and if that customer can convince the Local Authority to consent to its construction, then this cheap option will always win such contracts.

Use of pre-fabricated buildings is a form of material substitution. This option can improve the environmental performance of the construction process. However this benefit is offset by loss of amenity due to "ugliness" of final

buildings. Furthermore, whether benefits are appreciated in a broader context depends on pollution and resource use arising from manufacturing processes which make pre-fabricated materials.

Development of pre-fabricated buildings is reported to be limited to geographic areas where Local Authorities consent to their construction. In such areas, it may be expected that construction wastes are both reduced (due to less need for material processing on-site) and different in content (due to the different materials employed).

iii) Not all companies with BS: 5750 accreditation operate to the highest standards. Although some such companies could become de-registered, the degree of quality which BS: 5750 will support remains uncertain.

As with Barrier i) (p.155), this response emphasises the firm's progressive nature. This response suggests that the firm is relatively progressive even in the context of other firms registered for BS: 5750. The issue here is similar to that outlined in association with Barrier i) except that in this case comparison of firms *within* the set of firms seeking to exploit the top end of the market is involved.

In general terms this response highlights the issue that even when firms which operate to the highest standards are distinguished there will always be firms that are not as progressive as others. The principle of distinguishing firms that adopt best practice is an incentive for firms to improve standards. Uncertainty about how much improvement is required can cause some firms to respond to their best ability but can also lead to disenchantment of such firms if competitors are not forced to respond as much.

iv) Local Authorities can be misled by overly optimistic planning applications. Once a development is underway, Local Authorities only halt work if there is a strong protest from local residents. Firms that fail to meet standards laid out in planning consents may still complete contracts but they are unlikely to receive consents in the future from the same Local Authority.

Also **planning policies vary between Local Authorities** leading to regional diversity of enforcement standards which can be exploited by smaller local firms which operate to lax standards and at low cost. For example, some Local Authorities compromise their enforcement of standards if developments are likely to create a lot of jobs in the area.

As mentioned above, planning requirements are more associated with safety and amenity issues than with environmental performance during the construction process. However, this response is analogous to the condition identified in Section 6.4.7 that Local Authorities regulation of Waste Producers is inconsistent between Authorities. Identification of local employment needs as a reason is congruent with the case of environmental regulations varying between Local Authorities.

Variation of local regulatory conditions is very significant for large construction firms which construct buildings in many different areas subject to many local interpretations of regulations. It is unsurprising that this situation arises since

real differences between local areas and the requirements of local people should be incorporated into local planning requirements.

That "best practice" can be a locally interpreted has pro's and con's for Waste Policy formulation and implementation. Positive aspects include:

> Local variations in conditions can be accounted for (eg a local nature reserve may need to be protected).
>
> Firms operating in many local areas are likely to adopt practices which conform with the highest standards imposed.

Negative aspect include:

> Local firms may be able to exploit lax standards and export goods and services to other areas to the detriment of firms operating to higher standards (in the case of construction, it is the buyers of cheaper buildings in some areas that enjoy this benefit).
>
> Some local areas may attract more business geared to exploiting lax standards. Concentration of such businesses in one area (an industrial estate say) can make it more difficult for future regulators to improve standards.

7.4.2 Question 2: What current practices influence waste arising?

This question focuses on the processes of construction relevant to waste production rather than issues surrounding the construction business.

The Quality Manager based his response to this question on four major problems which he had identified in the course of waste auditing projects. He began by defining "waste" as **"financially unsound material use."**

(i) Material Supply

The first waste audit report identified over-supply of materials as a key reason for high waste management costs. Prior to the waste audit, all excess materials were eventually thrown in skips for removal by Waste Hauliers.

One recommendation of the waste audit which has been adopted is that wherever possible (ie. if no extra cost is involved), materials should be ordered on a returnable basis. Unfortunately this is only possible for orders placed with the firm's subsidiary material supply (which are delivered by the firm's subsidiary haulier). This includes bricks supplied to sites in the South-East of England. Other suppliers are either unable to arrange for hauliers to pick up returned materials or charge more to provide the service than the cost of removing the materials as wastes in skips.

Subsequent waste audit reports noted the failure to arrange economic return of excess materials and recommended that material orders be more closely

tailored to the needs of site managers. One common practice was for buyers to place large orders if suppliers offered a reduced price for orders of a certain size. Waste audit reports showed however, that small savings achieved in material costs are more than offset by increased costs of waste removal. Consequentially, buyers are now instructed to only place orders that exceed requirements if the difference in volume involved is small. This means that materials with a high value to size ratio are still ordered in bulk whereas less valuable materials (such as breeze blocks) are ordered in close consultation with Site Managers.

One problem discovered in implementing this change of policy was that Site Managers and Sub-Contractors had become used to over-supply of materials. Two other recommendations of the waste audit relate to this problem. These recommendations are outlined below ("appropriate use of materials" and "policing of Sub-Contractors").

Tailoring material supply to the requirements of construction activities is a form of waste minimisation. That this option requires additional supervision of site-operatives is a good example of how waste minimisation options can require changes to waste producing processes and exploitation of internal skills (in line with the model presented in Section 6.4).

Early attempts to arrange return of excess materials are a form of recycling (materials which would otherwise be treated as wastes are collected for re-use by external agencies). However, interactions with external agencies (in this case Material Suppliers) could not be exploited to implement this option fully. In this case, the benefit of waste minimisation over recycling arises from the firm's ability to deploy internal skills more effectively than interactions with Material Suppliers to achieve the same result. Note that in the case of returning materials to the firms subsidiary supplier the option is waste minimisation rather than recycling within boundary conditions of the firm.

(ii) Appropriate Use of Materials

On building sites it can be convenient to use higher grade materials than are necessary for a job if those materials are close to hand at the time. For example, a brick layer building an inner wall might start using facing bricks rather than plain bricks if his stock of plain bricks runs out. Internal studies showed that time savings achieved are usually less valuable than materials losses. This kind of problem is referred to as "indirect wastage" by the Quality Manager.

Indirect wastage is linked to over-supply of materials because over-supply of high grade materials encourages and enables their inappropriate use. To reduce over-supply of a material, one must also prevent its inappropriate use. Inappropriate use is one of the problems addressed by the third recommendation ("policing of Sub-Contractors," outlined below).

Appropriate use of materials is a change to the process of construction which enables the waste minimising option to be implemented.

(iii) Policing of Sub-Contractors

The waste audit recommended improved policing of Sub-Contractors by site managers for three reasons:

To reduce inappropriate use of materials
To prevent abuse of waste facilities by Sub-Contractors
To prevent contamination of wastes by Sub-Contractors

The first reason is outlined in the preceding recommendation.

The second reason stems from research undertaken by the Quality Manager which showed that some Sub-Contractors often arrive on site with waste from other jobs:

"They all run small jobs on the side."

(The Quality Manager)

As a main contractor, the firm is legally obliged to provide for storage and collection of wastes arising from Sub-Contractors' operations on site. Clearly, the firm is justified in preventing Sub-Contractors from disposing of wastes from other jobs in facilities provided on site.

The research undertaken by the Quality Manager also showed that Sub-Contractors use on site waste facilities to discard equipment which is still functional. A further recommendation which has been adopted is that buyers now issue Sub-Contractors with contracts which state that;

"facilities provided for wastes on site shall not be used to discard Sub-Contractors plant and equipment."

(The Quality Manager)

The firm accepts responsibility for; packaging, spent materials, disposable roller heads etc., but it considers such things as; re-usable roller handles, tamping boards, palates and anything still usable to fall under "Sub-Contractors plant and equipment."

Hence policing of subcontractors use of waste facilities is another waste reduction option for the firm. Of course, Sub-Contractors must still find their own means to dispose of whatever they consider as wastes. When asked whether Sub-Contractors reuse equipment, find an alternative easy means of disposal or arrange and pay for the removal of these materials (and hence charge higher rates for their services) the Quality Manager recommended that these questions be addressed to the Site Manager.

The third reason for improved policing of Sub-Contractors stems from a recommendation of the legal department for site managers to ensure that:

"Operatives and Sub-Contractors do not unnecessarily contaminate waste with substances which are not innocuous Builder's Waste."

(The Quality Manager quoting the Legal Adviser)

"Builder's Waste" is the description of skip contents given to Waste Hauliers in waste transfer documents. The Quality Manager said that the firm is legally

obliged to ensure that this description is accurate. Policing of Sub-Contractors' use of waste facilities is the firm's way of discharging this responsibility. However, the definition of "Builder's Waste" remains a legal grey area. The Legal Adviser to be met that afternoon is responsible for interpreting Duty of Care legislation in the context of the firm's activities. The Quality Manager recommended that questions concerning this issue be addressed to her.

Policing of Sub-Contractors is the particular deployment of internal skills which in this case enables the changes to the process of construction to be achieved which are necessary for the implementation of waste minimisation. In this case, policing of Sub-Contractors yields additional benefits for the firm in terms of preventing abuse of waste facilities (contributing to waste minimisation) and preventing contamination of wastes (contributing to satisfaction of regulatory requirements).

(iv) Separation of Compressibles

The Quality Manager had researched the possibility of removing compressible wastes for separate collection. Given that skip hauliers charge a price per skip removed and given that compressible wastes take up a lot of skip space for a small weight of material, it was expected that savings might be achieved by separating compressible wastes and compressing them prior to removal.

During a waste audit of a large supermarket construction site, the Quality Manager assembled data about the compressibility of wastes produced. For each job performed on the site, he assessed wastes as compressible or incompressible and as constituting; low (less than a third), medium (one to two thirds) or high (more than two thirds) proportions by volume of wastes produced in each job.

He found that early phases of construction involve jobs that produce low proportions of compressible wastes (jobs such as concreting and blockworking). Furthermore these jobs produce high density wastes which serve to compress any compressible wastes in skips. During later phases of construction, finishing work such as tiling, carpentry, glazing and carpeting, produces high proportions of low density wastes which are not automatically compressed in skips by other wastes produced on site at the same time.

If this waste could be compressed and removed at the same unit rate (per skip), then the Quality Manager estimated that for the construction site audited, savings of around £25,000 out of a waste management bill of £200,000 would have been possible. This saving represents a contribution to profit of approximately two percent. The fact that it does not reduce product quality however makes it worthwhile for the firm despite the relatively small sums of money involved.

Implementing this option proved difficult though. Skips which compress wastes are expensive to purchase (around £200,000). Haulage firms are unwilling to provide such skips for use on construction sites due to risks that they might be damaged. Alternatively, compressible wastes can be collected by vehicles which compress wastes during loading (like domestic waste collection vehicles). These

compression vehicles are expensive to purchase and many haulage firms are concerned that they will be damaged if they are sent onto construction sites.

The Quality Manager said that during the later phases of construction, site access is excellent and there is little danger of damage due to accidents involving heavy equipment or falling masonry since activities which might cause such problems are not continued during the later stages of construction.

This argument has been put to hauliers but only one firm even offered a quote. The initial quote for removal of compressible wastes was very high (around £50,000) per site. Eventually the quote was negotiated to similar rates per unit volume as for skip removal, by offering the haulage firm a contract to remove all skip waste as well as compressible wastes on sites where compression is viable.

As a general rule, the firm now separates compressible wastes during the later stages of large jobs which involve more than £100,000 waste costs.

This option is difficult to categorise. It can be considered as "waste removal service substitution," "waste volume minimisation" or simply as "appropriate waste management." Since it does not result in reduction of material used in the process of construction it is confusing to consider it as related to waste minimisation. As a form of substitution, it does involve the characteristically strong involvement of suppliers but it does not affect resource use or pollution associated with construction processes. As a form of appropriate waste management, it should be noted that benefits only arise during waste haulage. Eventually the waste is sent to landfill along with other construction waste. If the packaging waste were sent to an alternative destination (such as an incinerator) then the distinction would be more clear cut.

Despite difficulty in identifying the practice of separating compressible waste, it does serve as a good example of how changes to Waste Producer practices that require interaction with external agencies can involve considerable effort and dedication by staff in waste producing firms.

7.4.3 Question 3: What legislative pressures influence the company's waste policy?

This question is used to identify particular regulatory mechanisms which influence Waste Policy formulation and implementation for this construction firm.

The Quality Manager outlined the following legislative issues which he had encountered when conducting waste audits:

(i) The Duty of Care

As mentioned in the Quality Manager's response in Section 7.4.2 (response (iii)), the firm seeks to ensure that Sub-Contractors do not contaminate waste skips designated as "Builder's Waste" with substances that are not innocuous.

The Duty of Care is supposed to be implemented by Local Authorities. The only cases (known of by the Quality Manager) of Local Authority prosecution regarding "Builder's Waste" have involved prosecution of Waste Hauliers following spot checks of vehicles in transit organised by Local Authorities in conjunction with the Police Force. Despite the lack of direct prosecution against building firms, the firm still seeks to minimise the risk of any such action since any prosecution would damage the firm's reputation with Local Authorities.

The Quality Manager recommended that the Duty of Care be discussed with the Legal Adviser and with the Buyer.

Interpretation of information provided by the Legal Adviser is presented in Section 6.4.9. The Quality Manager's response suggests that the Duty of Care is not forcefully regulated in the construction sector. However this firm, according to its rational of satisfying Regulatory Agencies and due to its generally progressive nature, does not intend to risk prosecution.

(ii) Health and Safety Considerations

Recently, Health and Safety inspectors have taken more interest in the contents of skips. They are particularly concerned that flammable materials, any gas cylinders and any materials covered by COSHH (Control Of Substances Hazardous to Health) regulations are not stored in open skips. Such wastes must be stored separately and be secured against fire and theft. The firm stores such wastes in locked cabins.

This response demonstrates how regulation not directly intended to improve environmental performance can still influence Waste Policy formulation and implementation. Separation of hazardous materials makes wastes arising from construction activities less of a problem for waste managers during subsequent treatment, disposal or recycling.

(iii) Vehicular Access

Local Planners and Police Forces impose restrictions on vehicular access. Vehicular access may be restricted by:

Number of entrances and exits allowed

Size of vehicles allowed (in terms of height, width, length and/or weight)

Number of vehicles allowed (in terms of vehicles per hour, vehicles per day and/or restrictions to certain times of day)

For any site, the Police Force may impose one set of restrictions whilst the Local Authority imposes another. The firm must ensure that both sets of conditions are complied with.

These restrictions often influence waste costs. For example, if a job involves excavation, it is cheapest to hire a large lorry which can remove waste soils in a few trips. If vehicle size restrictions prevent this, then use of skip vehicles (which are always allowed on sites) to remove such wastes increases waste costs.

Often, the firm is restricted to using skips for waste since restrictions are usually stipulated in terms of how many or how frequently skip loading vehicles may visit the site. Unless a height restriction is also imposed, the firm tends to use skip vehicles that can stack two skips in one load.

When asked if such restrictions affect the use of compression vehicles, the Quality Manager replied that they have not done so yet. He thought that towards the end of jobs, vehicle restrictions are eased since traffic around sites is minimal at such times and local concern about the site is less. A problem is only likely if narrow or weak roads or low bridges physically prevent access.

This response also demonstrates how regulation not directly intended to improve environmental performance can still influence Waste Policy formulation and implementation. In this case however, it is not the quality of waste which is affected but the form in which it is removed.

Vehicle regulations tend to limit waste removal from construction activities to skip loads. Access limitations are a condition which limits the choice of options for waste management since, sophisticated streaming of waste at source would require use of more containers (and hence more vehicles to remove containers). More containers could be stored on site for a longer time to maintain a low average frequency of vehicular access. However, with a larger number of containers on site, it is more likely that several containers would need to be removed around the same time, thus increasing the likelihood of failing to meet immediate access requirements.

By generating a minimum number of waste streams, construction firms are able to ensure that container capacity is robust regarding waste produced. In other words, if one skip gets full, it is not difficult to find another skip for the same type of waste.

7.4.4 Question 4: What technological options are known of and how are they assessed?

This question is used to elicit information regarding costs and benefits of different waste options appreciated by construction firms. It was expected that responses would tend to address financial costs and benefits since "achieving environmental improvement at least cost" is identified as a low level objective of Waste Producers in general in Section 6.4.1.

The Quality Manager had already outlined technological options which he repeated as:

Policing of subcontractors to reduce indirect wastage on sites

Improved management of material supplies quantities

Separation of compressibles

Separation of hazardous and toxic wastes

In general, these options require more active intervention by Site Managers the larger the job is. In fact separations of compressible, hazardous and toxic wastes are only performed on large construction sites. This is because the quantities of such wastes on smaller sites does not justify separate storage and removal and because site inspectors are less concerned about the relatively small amounts of waste arising from small sites.

Regarding assessment of options the Quality Manager said that all options have to be cost effective. The waste audit is essential for cost estimates since it provides data on how much waste is produced by each specific job on a site.

Use is also made of trade contacts and journals to ensure that options developed in other companies are not ignored. For example reduction of indirect wastage is a technique copied from another firm.

The Quality Manager asked for suggestions of other options that might reduce wastes and the following three suggestions were made:

> Use of recycled materials - which might not reduce wastes but which might reduce material costs and provide a market for building wastes to be recycled.
>
> Separation of hardcore and soils - which could be sent more cheaply to landfill sites for use in temporary road building and as daily cover material.
>
> On site re-use and recycling - to reduce wastes and to reduce material requirements.

The firm is considering specifying recycled materials for packaging used by some suppliers. This is being pursued as a possible contribution to achieving BS: 7750 (environmental management) accreditation. Other recycled materials though are considered as likely to reduce quality in final buildings.

> "Customers prefer a building that will last to one which is recycled."
> (The Quality Manager)

If material suppliers can show that recycled materials meet specifications then, if they are competitively priced they would be considered. If a supplier also offers cheaper waste removal then that would be taken into account.

Regarding separation of hardcore and soils, the Quality Manager was surprised to hear that they could be sent to landfill sites more cheaply than other wastes. If construction jobs involve excavation, large quantities of such materials are removed from the site uncontaminated with other materials. Hauliers only offer reduced prices for such materials on the basis that larger vehicles can be used to remove them.

This provoked a conversation about Waste Hauliers in general during which the Quality Manager reiterated the facts that:

> they only offer quotes on a price per skip (regardless of the weight of materials involved)

> Waste Hauliers were unreceptive to the suggestion of providing compression vehicles

He also voiced the opinion that Waste Hauliers operate local cartels which keep removal prices high and offer little choice in services offered.

> "They only provide a choice between single loading or double loading skip vehicles or large wagons during excavation stages of projects."
> (The Quality Manager)

The Quality Manager said that he would investigate the possibility of changing the waste description for excavation wastes if that would reduce costs.

On site re-use and recycling is an issue for Sub-Contractors. If they can engage in such activities and maintain competitive tenders then it will happen. Most Sub-Contractors do not have the technological sophistication to develop radical alternatives but some already reuse materials. For example, it is standard practice to save large plastic sheets used to cover brick deliveries for use as damp course materials in foundations.

This response confirms this firm as a firm which considers cost as the key factor in assessing waste options. Recall that the Quality Manger defines waste as *"financially unsound material use"*.

It is interesting to note that Waste Hauliers do not seem to transmit costs and benefits they appreciate regarding different kinds of waste to their customers in the construction sector. This subject is investigated further in Chapter Eight.

This Section also re-emphasises the strong focus on product quality which drives the firm.

7.4.5 Question 5: What weighting other than financial costs and benefits (if any) are given to environmentally pro-active options?

Given the expectation that Question 4 would be responded to in financial terms, this question was used to determine what other factors, if any, are considered by the firm when assessing waste options.

Over and above cost and legal liability considerations, the following additional considerations influence the firms operations:

(i) Energy efficiency of finished buildings

Any option which improves insulation and ventilation of buildings is negotiated with customers early on. Small quantities of insulation materials are usually discarded with general wastes. Although some of these materials can be hazardous they have not been isolated by health and safety inspectors as unsuitable in skips.

(ii) Public Relations

Due to public sensitivity regarding new developments, the company is keen to promote a positive image towards local issues such as traffic congestion, noise, noxious smells and dust. This image is useful for obtaining planning consents from Local Authorities.

Response (i) again emphasises the important role of customer satisfaction as an objective for this firm. Response (ii) identifies satisfaction of requirements of local residents as a relevant objective for the firm. This objective is only identified in responses to other questions as pertinent to customers of the firm.

7.4.6 Question 6: What problem wastes are identified by the company, why do they pose a problem and what is done to alleviate problems?.

Given that the Quality Manager had already identified problem wastes and action taken by the firm in response to Questions 3 and 4 this question is somewhat redundant. The Quality Manager briefly re-iterated the following points:

> Flammable materials, any gas cylinders and any materials covered by COSHH regulations or identified by Health and Safety inspectors are problem wastes
>
> Such wastes must be stored separately and be secured against fire and theft according to health and safety inspectors.
>
> The firm stores such wastes in locked cabins and is insured against accidents which they may cause.

7.4.7 Discussion

The discussion which followed the Quality Manager's presentation served two purposes:

> To clarify issues raised during the presentation (in which case the information is included above)
>
> To determine appropriate topics for discussion at the other meetings arranged (these topics are presented below)

For the meeting with the buyer and the site manager, the following topics were decided upon:

1 **To clarify difficulties with material supply:**

> Problems with returning excess orders to suppliers
>
> Problems with tailoring orders to site requirements whilst seeking bulk bargains

2 **To clarify how Sub-Contractors are policed on site**

How Sub-Contractors are encouraged to reduce inappropriate use of materials and to reduce abuse or contamination of waste facilities

How Sub-Contractors deal with wastes that are no longer the responsibility of site managers

3 **To discuss the Duty of Care and what it means for the buyer and the site manager**

4 **To discuss how restrictions on vehicular access influence waste removal from sites**

5 **To discuss choices offered by Waste Hauliers (if any) in services for construction waste removal**

For the meeting with the legal adviser it was decided to focus solely on the issue of the **Duty of Care and what it means for the firm.** This was because the legal adviser to be met has taken responsibility for interpreting Duty of Care legislation and she recommends any action which must be taken by the firm.

7.4.8 Meeting with a Buyer and a Site Manager

The meeting with the Site Manager and the Buyer lasted for one hour and focussed on the topics outline above, presented in the order given. The information is briefly summarised if the content simply confirms the responses given by the Quality Manager.

Topic 1: To clarify difficulties with material supply:

Problems with returning excess orders to suppliers

Problems with tailoring orders to site requirements whilst seeking bulk bargains

The Buyer responded by saying that getting suppliers to pick up excess orders is not feasible because most suppliers deliver only once to a site unless they supply perishable materials in which case they do not want them back.

When asked about the firm's subsidiary supplier he said that the arrangement mentioned by the Quality Manager is no longer used.

The Site Manager added that if one site has over-ordered it is sometimes possible to find another site that is nearby and short of the materials involved. This is a form of recycling which relies on informal interactions between Site Managers.

Regarding the tailoring of orders to site requirements the Buyer responded that his job is to order what has been requested. He recognised the recent change in policy which from his point of view means that if a bulk bargain is available he consults the Site Manager involved before ordering.

The Site Manager said that the new internal order forms involved are a great improvement. For example, old forms restricted managers to ordering materials in blocks of say one hundred units whereas new forms allow more specific orders to be placed. Over-ordering didn't just cause problems for waste management on sites but also caused problems by cluttering the site with unnecessary materials.

Topic 2: To clarify how Sub-Contractors are policed on site

How Sub-Contractors are encouraged to reduce inappropriate use of materials and to reduce abuse or contamination of waste facilities

How Sub-Contractors deal with wastes that are no longer the responsibility of Site Managers

The Site Manager responded by saying that it depends on how large the site is as to what measures are required to police Sub-Contractors. On smaller sites it is easy to keep an eye on everything and more time can be spent with individual

Sub-Contractors to specify particular materials for particular jobs. For larger sites, he mentioned the following factors which make policing difficult:

> Separate material storage locations and skip locations are dispersed around the site
>
> Sometimes the firm is not the only main contractor on site responsible for materials and skips
>
> More management time is spent seeing that Sub-Contractors are actually doing jobs they are supposed to which leaves less time to supervise how they do the jobs and where they put their wastes.

The Buyer added that contracts with Sub-Contractors have been re-written to make them responsible for any materials which are not purchased by the firm from material suppliers or specified (in contracts) as **"materials"** to be purchased by Sub-Contractors.

The Site Manager replied to this by saying that he was unsure as to his position because his job makes him responsible to ensure that *all* wastes leaving the site are properly disposed of.

When asked about whether Sub-Contractors have questioned the new contracts or offered higher rates as a consequence, the Buyer said that none have.

Topic 3: To discuss the Duty of Care and what it means for the Buyer and the Site Manager

The Buyer said that his department is currently preparing forms to request information regarding materials supplied from Material Suppliers. Suppliers already provide Health and Safety data sheets which outline handling requirements and health risks for their products. The idea is for them to provide similar information on how their products and packaging should be handled as wastes. The key question to be asked of suppliers is whether materials and packaging can be put in skips described as containing "builders waste" and sent to landfill and if not, then what should be done with them?

The Site Manager said that he really is not sure about the Duty of Care. On the one hand he has to ensure that skips on site are not contaminated with any noxious materials. On the other hand, where separate skips are provided for noxious materials then they get taken to a landfill site anyway. When separate skips aren't used, there is only a small amount of noxious materials in skips anyway. For example a skip might contain half a dozen paint tins and tub of soiled solvent if it is near to a painter on site.

On larger sites a few separate skips are provided for noxious wastes, but it is difficult to get Sub-Contractors to use them if they are further from where they are working than another skip. They also tend to be filled up with non-noxious waste as general waste skips become full.

Topic 4: To discuss how restrictions on vehicular access influence waste removal from sites

The Site Manager said that restrictions which affect wastes usually occur during a job rather than in advance. Often restrictions involve a particular kind of vehicle which has been complained about by local people and sometimes those are skip vehicles. There is no negotiating such restrictions but they can be circumnavigated by storing more skips on site and waiting until the end of jobs to clear the site.

On sites in certain areas of London, restrictions are so severe that wastes can be stored on sites for up to two weeks after construction is complete.

Topic 5: To discuss choices offered by Waste Hauliers (if any) in services for construction waste removal

The Buyer said that Waste Hauliers are notorious for providing no choice. They provide their worst skips and their worst vehicles for construction sites.

When asked about the compression vehicles he said that the haulage firm in question is an exception because it is a professional firm that operates nationally and has only recently targeted construction sites for business. This haulier is not used for jobs where compression vehicles are not needed since its is more expensive when compared with other firms that move skips.

In summary, this section supports the responses given by the Quality Manager and provides some extra detail regarding implementation of waste options.

7.4.9 The meeting with the Legal Adviser

This meeting was arranged to discuss the Duty of Care and what it means for the firm.

The Legal Adviser was busy at the time arranged for the meeting. However, she supplied copies of three memoranda which she had issued within the firm and a letter sent to an MP which address issues regarding the duty of care. Relevant quotes from these are presented below.

A "The Buying Department will ensure that no orders for the collection and transportation of waste are placed with any persons other than registered carriers. The Buying Department is also in the process of amending the Tender Enquiry Documents in respect of all Sub-Contracts to place upon the Sub-Contractor the responsibility for controlling and disposing of their own waste by registered carriers."

(Memo 1)

This is a statement of the obligation which the Duty of Care places on the firm and a statement of the firm's Waste Policy regarding Sub-Contractors' waste.

B "Site Managers... Upon being notified by the Buying Department that an Order has been placed with a registered carrier for the removal of waste, Site Managers will ensure:

(a) All waste and surplus materials are collected and stored in proper containers on the site.

(b) All waste and surplus materials are transported away from the site by a registered and certified vehicle, which cannot spill the material whilst in transit."

(Memo 1)

This is a statement of measures to be taken by Site Managers to implement the firm's Waste Policy as regards the Duty of Care. The conflict between the requirement expressed in Quote A that Sub-Contractors should be responsible for their own waste and the requirement expressed in Quote B that Site Managers ensure that all waste and surplus materials are transported from the site by a registered carrier is the source of confusion arising from the firm's Waste Policy which the Site Manager referred to (as reported in Section 7.4.8).

C "I have been having a series of discussions with *"Mr. A, Mr. B"* and various Project Managers as to the problems that they have been encountering in complying with the new legislation. Apart from *"Mr. A"*, who believes that there will be some difficulty in ensuring that Sub-Contractors do not dispose of hazardous or toxic waste in containers set aside for general builder's rubble, all have said that save for some 'administration' the new procedures are not having any adverse effect on their operations. Similarly *"Mr. C"* has informed me that no site he has visited has reported any problems."

(Memo 2)

This quote suggests that the main problem with implementing Waste Policy is due to difficulties of policing Sub-Contractors.

D "Apparently the Department of the Environment was not swayed by the argument that no-one wanted to be first 'guinea pig', and it is up to individual Contractors to decide what steps they need to take to satisfy the Duty of Care. This means that prudent Contractors will include for it in their tender prices, whilst others will simply take a chance."

(Memo 2)

This quote highlights a consequence of the UK Government's adoption of a market based approach to the polluter pays principle. The "first guinea pig" refers to the fact that little guidance or precedence is available for firms to judge the degree to which they should seek to improve waste practices. This issue is returned to below.

E "RE: BEC's sectoral Business Bulletin - [the journal of a construction sector trade organisation]

... it would seem that *"the firm"* are taking all such measures as are applicable to it as 'are reasonable in the circumstances' to avoid breaking the law."

(Memo 2)

In the absence of guidance or precedence, this firm has sought to ensure that it is adopting measures in line with those adopted by other firms.

F In a later memo -

"A Waste Management Committee comprising *"Mr. B, Mr. C, Mr. D"* and the writer was set up in March to consider the effect the new legislation would have on procurement and site management procedures, and to facilitate its implementation. .... To date there have been no reported problems in complying with the legislation, but it is intended to continue to monitor the situation."

(Memo 3)

In contrast with Quote B, problems with policing Sub-Contractors are no longer referred to (note that Mr. A, who identified this problem, is not on the Waste Management Committee).

G "We do not believe that proper or adequate consideration has been given to the impact that the duty of care has, both in terms of significant increase of cost and also in management time, on construction operations. Although construction activities have been mentioned in the Code of Practice, it would seem that they have been dealt with in a facile and somewhat arbitrary manner without regard to actual conditions prevailing in the industry."

(Letter sent to MP)

This quote shows that the firm is somewhat concerned about the lack of guidance and precedent by which to formulate appropriate Waste Policy. The clear issue is how much money and effort firms should spend in order to comply with regulations and whether it is worth making more of an effort than competitors do.

H "... the Duty of Care requires the waste to be 'described'. We have been unable to obtain guidance as to precisely what will suffice by way of a 'written description'. It could mean that each constituent item of waste in a skip load has to be listed and quantified, ie 'Xkg of brick, blocks, timber off-cuts, glass ceramics, carpeting' or it could mean 'one 6cu.yd skip of builder's rubble". At the moment, skip haulers and waste disposal Site Managers appear to be content with the broader description, but until there is legislative or judicial authority on this point we appear to be at risk."

(Letter sent to MP)

This quote re-emphasises the main issue of shortage of guidance and precedent and also suggests the kind of alternative "description" which the firm would consider appropriate for construction waste. Note that since the interviews were conducted, waste producing firms in the construction sector have been prosecuted and precedent has established that any harmful material in skips as illegal (ENDS June 1994 p.45).

I Regarding Sub-Contractors and Waste Hauliers -

"We will be heavily reliant on the organisational procedures of third parties over whom we have no control and who by their very nature are not noted for the sophistication of their own management systems.

According to the Act, only authorised waste carriers may transport waste. How are Contractors to deal with a situation where a Sub-Contractor, elects to provide his own vehicles to remove his waste materials "

(Letter sent to MP)

This quote addresses the concerns about policing Sub-Contractors and re-iterates the problem of whether the firm can legally allow Sub-Contractors to remove their own wastes.

J "We have been informed by the BEC that the Department of the Environment, although acknowledging that there are ambiguities in the legislation and Code of Practice, are not prepared to give more precise directions or provide clarification as to how the legislation will be applied, on the grounds that this will be a matter for judicial interpretation when cases start to come before the courts. If our source of information is correct, and we have no reason to doubt it, such an attitude is deplorable and serves only to lend weight to the view that insufficient thought has been given to this subject."

(Letter sent to MP)

This quote shows that the firm is considerably anxious to receive guidance as is appropriate for a firm which seeks to develop as pro-active in terms of meeting regulatory requirements.

K "Another legal requirement which the legal department do not consider well interpreted is the duty to insure (by use of transfer notes) that waste "is deposited only at licensed disposal sites""

(Memo 3).

Memo 3 goes on to point out that most construction waste is sent to transfer stations for bulk loading prior to removal to waste disposal facilities. Transfer station operators are unable to provide return information about which delivery of skip waste has gone to which disposal site after loads have been mixed.

This quote highlights the role of Waste Hauliers and the apparent shortage of return information they provide concerning disposal options. One reason behind this seems to be the use of transfer stations. However, it should be noted

that transfer stations can now be licensed as disposal facilities which should help to clarify the legal problem identified in Quote K.

7.5 Summary

In Section 6.4.1 it is shown that a relevant low level objective of Waste Producers in the context of Waste Policy formulation and implementation is "achievement of environmental improvement at lowest cost." The responses reported in Section 7.4 suggest that a more suitable objective for construction firms is to "satisfy customer requirements regarding quality at lowest cost." Customer requirements may include environmental characteristics of finished buildings but do not seem to include consideration of the construction process. The quality objective is also reinforced by construction regulations which focus on quality of final buildings.

Relevant regulations regarding the process of construction tend to focus on safety and local amenity issues rather than environmental issues directly. However, requirements to separate hazardous wastes (especially enforced on large construction sites) do influence waste practices as do vehicle access restrictions.

The firm surveyed is particularly concerned about Duty of Care legislation and is taking steps to improve management of waste on construction sites. However, this firm is particularly progressive in its approach to regulatory compliance and the low levels of prosecutions of construction firms known of within this firm suggest that other less progressive firms may not employ similar high standards of waste management.

It seems that Waste Hauliers to the construction sector offer a fairly basic service which does not discriminate between different kinds of waste. Although construction firms are appreciating general increases in waste management costs, they are not aware of price incentives already offered by Waste Managers for certain kinds of waste. This factor limits the ability of construction firms to appreciate opportunities that involve exploiting benefits perceived by Waste Managers associated with different kinds of waste. This factor and vehicle access restrictions are conditions which limit construction firms to producing a few aggregated waste streams rather than developing sophisticated forms of source separation. The case of separating compressible materials is an exception which required significant dedication by the Quality Manager as well as in depth bargaining with Waste Hauliers.

Awareness of increasing general costs of waste management has prompted the firm surveyed to adopt waste minimisation options. The example identified does involve the characteristic process changes and employment of internal skills represented in the model presented in Section 6.4. Involvement of Sub-Contractors in the construction process adds an extra level of interaction which in this case is perceived as a surmountable problem.

Measures taken by the firm to improve waste practice in terms of preventing contamination of skip waste are also difficult (but not impossible) to implement due to involvement of Sub-Contractors. However, lack of regulatory guidance and precedent does make the firm surveyed wary of spending too much effort in

this regard since less progressive competitors may exploit cost savings achievable by adopting less pro-active responses.

In terms of information relevant to this case study, the information presented in Section 7.4 indicates the following factors as important determinants of the content of "builders waste":

> "Builders' waste" is likely to continue to arise in skip loads of mixed wastes.
>
> If separation of compressible materials becomes popular in the construction sector then skips of "builders' waste" are likely to contain a larger fraction of materials suitable for recycling into hardcore and cover material.
>
> In some areas, where construction of pre-fabricated buildings is popular there may be less materials contained in "builders' waste" suitable for recycling into hardcore and cover material.

Considerations regarding Waste Policy formulation and implementation in a more general sense which are exemplified by information presented in Section 7.4 include:

> Although the Duty of Care does promote improvement to waste practices in progressive firms there is no guidance as to what constitutes "suitable descriptions of wastes." Although IPC legislation contains similar vaguely defined phrases such as "Best Available Techniques Not Entailing Excessive Cost," the provision of guidance by HMIP serves to clarify what is required of firms. A similar approach for Duty of Care legislation would involve guidance for particular industrial sectors regarding waste descriptions.
>
> Firms with a professional and progressive outlook play an important role in developing new forms of best practice. In sectors which focus on quality and customer needs, such progressive behaviour is supported by existence of market niches for high quality goods and services and/or goods and services with sound environmental characteristics. Development of voluntary schemes such as BS: 5750 (quality management) and more recently BS: 7750 (environmental management) can reinforce such trends and help generate some degree of standardisation focused on good practice and generate higher degrees of customer expectations in such niches.
>
> Markets are diverse, and there are always market niches consisting of customers more concerned about price than quality or environmental performance. Although new legislation seeks to reinforce adoption of good practices in industry, not all sectors receive regulatory attention in this respect. The construction sector for example, is not historically associated with environmental problems and regulatory attention focuses on issues such as quality, safety and local amenity.

Despite an absence of regulatory focus on environmental issues regarding the process of construction, the information presented in

Section 7.4 does highlight issues regarding diversity of standards of enforcement of regulations between Local Authorities. Local Authority supervision does enable local issues to be accounted for in planning procedures. However, some local issues such as employment can give rise to situations where less consideration is given to environmental issues by some Local Authorities. In such areas, firms exploiting market niches at the low cost end of the market are able to thrive.

7.6 Conclusions

It may be said that legislation focusing on promotion of good practice does improve standards in progressive firms. This process relies on some vagueness of definition in legislation which allows firms to experiment with new techniques that legislators would not have been able to identify, let alone stipulate in the historical "command and control" regime. However, such vagueness can also be exploited by less progressive firms, giving rise to at least two tiers of practice.

New forms of legislation do include mechanisms for standards to be improved across a whole sector once improvements are demonstrated as practical and worthwhile. However, such standardisation requires significant effort on behalf of regulators which has only been demonstrated in sectors where environmental issues have a high profile. Meanwhile, other sectors are regulated on a local basis which has the benefit of allowing local issues to be incorporated into planning policy. However, there is a balance to be struck between environmental and other local issues which is, understandably, not always resolved in the interests of the environment.

More progressive firms are aware of less progressive competitors and, in sectors which are not subject to high degrees of regulatory enforcement it is for the progressive firms to determine how much to improve standards and how muchÂ to maintain low costs and remain competitive. In this environment, it is understandable that progressive firms focus attention on options that reduce costs. Section 7.4 provides a good example in the case of policing Sub-Contractors which not only enables the firm to ensure that wastes are not contaminated but also enables reductions in indirect wastage arising from inappropriate use of materials (waste minimisation) and prevents abuse of waste facilities by Sub-Contractors using them to dispose of wastes for which the firm is not responsible.

The findings of Section 7.4 suggest that in sectors which are not subject to high degrees of regulatory attention focused on environmental issues that Waste Policy formulation and implementation is still pursued by progressive firms but that improvements to waste practice are limited by the confidence of such firms that competitors will eventually follow suit or that customers will pay for improvements. Progressive firms are likely to focus on options which reduce costs. Such options are more likely to include ways of changing processes within the firms control than options involving external agencies. This internal focus inherently favours options such as waste minimisation rather than options like external recycling since the latter requires involvement of external agencies. This does not mean that progressive firms will not respond to opportunities presented by external agencies. However, there are few such external agencies

to offer such opportunities in a climate where progressive agencies focus internally.

One kind of agency well positioned to present such opportunities is the Waste Manager. Waste Hauliers could play a similar role, but evidence suggests that most Waste Hauliers are less concerned about developing new alternatives than continuing to profit from established forms of waste removal. Waste Managers on the other hand, tend to be large firms with a good appreciation of reasons why certain wastes may be better managed than by landfilling them. BCWM are a good example of a progressive waste management firm seeking to identify alternative options to landfill.

Whether recycling wastes, of the type produced by the construction firm surveyed, presents a viable alternative to landfill for BCWM is the subject of Chapter Nine. In Chapter Eight a modelling technique is presented which represents some of the attributes of Waste Hauliers which are relevant from the perspective of Waste Managers to any options which may involve changes to price charged at landfill for different kinds of waste.

CHAPTER EIGHT

A Model of Landfill Catchment Areas

8.1 Introduction

It is argued in Section 6.5 that recycling may not be promoted to the same degree as other options because waste producing firms that can afford to and are able to develop appropriate infrastructure do not need to, whilst waste producing firm that need access to such infrastructure cannot afford to or are not able to develop it themselves.

It may be that Waste Managers are well positioned to develop the kind of infrastructure required for recycling options. Recall that the waste management sector increasingly consists of large well resourced firms (Section 1.3). Waste Managers are also aware of the costs of managing different kinds of waste in established disposal facilities and therefore they are also aware of potential benefits of alternatives such as recycling. For Waste Managers, investment in recycling plant and equipment must be financially justified. In the absence of governmental intervention to promote recycling, financial justification is governed by the market.

Supply of waste materials for disposal or recycling is largely dependent on the prices charged by Waste Managers on receipt of waste. In general, the less a Waste Manager charges for a particular kind of waste (relative to competing Waste Managers), then the more such waste should be delivered to that Waste Manager.

For a Waste Manager investment in recycling plant or equipment is justifiable if it contributes to their profit goal by reducing costs they experience to manage waste. Some recycling options may be justifiable at higher costs if government intervention subsidises recycling or if recycling operations can be located nearer to sources of waste production. The former condition is not likely according to current Legislative Policy. The latter condition suggests that recycling operations can provide a more local service than disposal facilities which suggests a relatively small scale of operation. Although small local recycling operations may be viable since savings in transport costs appreciated by Waste Hauliers can offset higher prices for waste management, this kind of operation is not attractive to Waste Managers because

> "many sites would be needed to capture an appreciable market, and that would involve a lot of effort in terms of management time and in terms of planning applications."
>
> (A waste disposal Marketing Manager)

For larger scale recycling operations, it was thought that suitable locations would be at landfill sites in order to minimise costs of transporting residual waste for disposal. Modelled benefits of a particular recycling operation at a landfill site are presented in Chapter Nine. In this Chapter, a model is presented which represents possible effects of changing prices charged for waste. This modelling activity is generally relevant to any waste management option which involves price changes that are expected to result in attracting waste from a larger "catchment area."

The model is applied in the case of an actual landfill site operated by BCWM. Although the parameters used are particular to one site (in the context of sites it competes with) the modelling technique is applicable to any site for which appropriate data is available. The model can also be applied in a qualitative way to consider the kinds of effect generated by price changes in terms of "catchment area" (Section 8.6).

In Chapter Seven it is argued that construction waste is likely to continue to arise in skip loads (Section 7.5). In this chapter, particular attention is paid to considering skip loads of "builders waste" to identify results appropriate to the case study. Results of research conducted to acquire data for the model which are pertinent to other kinds of waste are presented (Section 8.4) to inform any future research based on similar modelling techniques.

The objective of the modelling activity presented in this chapter is to represent effects of price changes at landfill sites in terms of increased "catchment area". This activity highlights general issues associated with pricing strategy of Waste Managers and provides information about the effects of price changes on "catchment area" for skip loads of builders waste (this information is used in Chapter Nine where the viability of recycling construction waste at a landfill site is assessed).

8.2 The Catchment Model

The amount of waste arising in a given area is not something which Waste Managers can control. However, Waste Managers can control the price they charge to dispose of wastes (or recycle them). The price charged should influence the attractiveness of a facility to Waste Hauliers.

Of course, Waste Hauliers will not travel any lengths to seek the lowest price since they appreciate costs over every mile that they haul wastes. Waste Hauliers may however compare prices charged at locally competing facilities, bearing transport costs in mind when choosing destinations for wastes.

The area around a landfill site within which Waste Hauliers are attracted to the site is called the "catchment area" for that site. The catchment model presented below enables catchment area to be estimated for varying values ascribed to;

Price charged at the landfill site

Prices charged at competing facilities

Location of competing facilities in relation to the landfill site

Cost of transporting waste

Consider two landfill sites, Site 0 and Site 1. Site 0 may be considered as determining an origin point and Site 1 may be described as at a range R_1 (measured in miles). Site 0 charges a price P_0 £'s per tonne of waste delivered and Site 1 charges a price P_1 £'s per tonne of waste delivered. Consider that the transport cost

for all waste loads is T £'s per tonne per vehicle mile travelled from a customer to either site.

An equation was derived from first principles to describe a line of cost indifference for hauliers considering which landfill site to use. The line is perpendicular to the line between Site 0 and Site 1. The perpendicular distance between the line of indifference and Site 0 is S_1 where:

$$S_1 = (R_1 - (P_0-P_1)/T)/2$$

Equation 8.1

The derivation of Equation 1 is given in Appendix 1

For a set of sites all considered as competing with Site 0, a set of lines can be determined which enclose Site 0 in a "catchment area." This is shown if Fig 8.1.

This can be considered conceptually using a three dimensional model. Consider a three dimensional space where the horizontal plane represents position (for landfill sites and customers) as a map does. Instead of considering the vertical dimension as spatial however, consider it to represent cost. For disposal of waste, hauliers appreciate two kinds of cost;

The price charged by landfill sites per tonne of waste.

The cost of transport per tonne of waste per mile travelled.

The cost of disposal can be represented as a point (call this point P) directly above the spatial coordinates of the landfill site, vertically displaced by an amount equal to the price charged. The cost of using a given landfill plus the cost of transport to the site can be represented in three dimensions as an upturned conical surface positioned above the site (with the tip of the cone at point P) with sides that slope away from the vertical at a gradient determined by the transport cost per tonne per mile.

This concept is represented in Fig 8.2 which shows the cost cones for two landfill sites. The line of intersection of the cones is a curve which is oriented in a vertical plane (the vertical plane is perpendicular to the horizontal line between the two sites). The projection of this line onto the horizontal plane is the "line of cost indifference" between the sites.

The area around Site 0 enclosed by lines of cost indifference determined for four competing landfill sites is shown in Fig 8.3 to be composed of set of components of area A_1 to A_4. Area A_1 can be expressed in terms of the distances S_4 and S_1 (derived according to Equation 1) and the angle subtended by the line joining Site 4 and Site 0 and the line joining Site 1 and Site 0 (call this angle $Z_{4,1}$). The area A_1 is derived in Appendix 2 as:

$$A_1 = (2S_4S_1 - (S_4 + S_1)\cos Z_{4,1}) / (2\sin Z_{4,1})$$

Equation 8.2

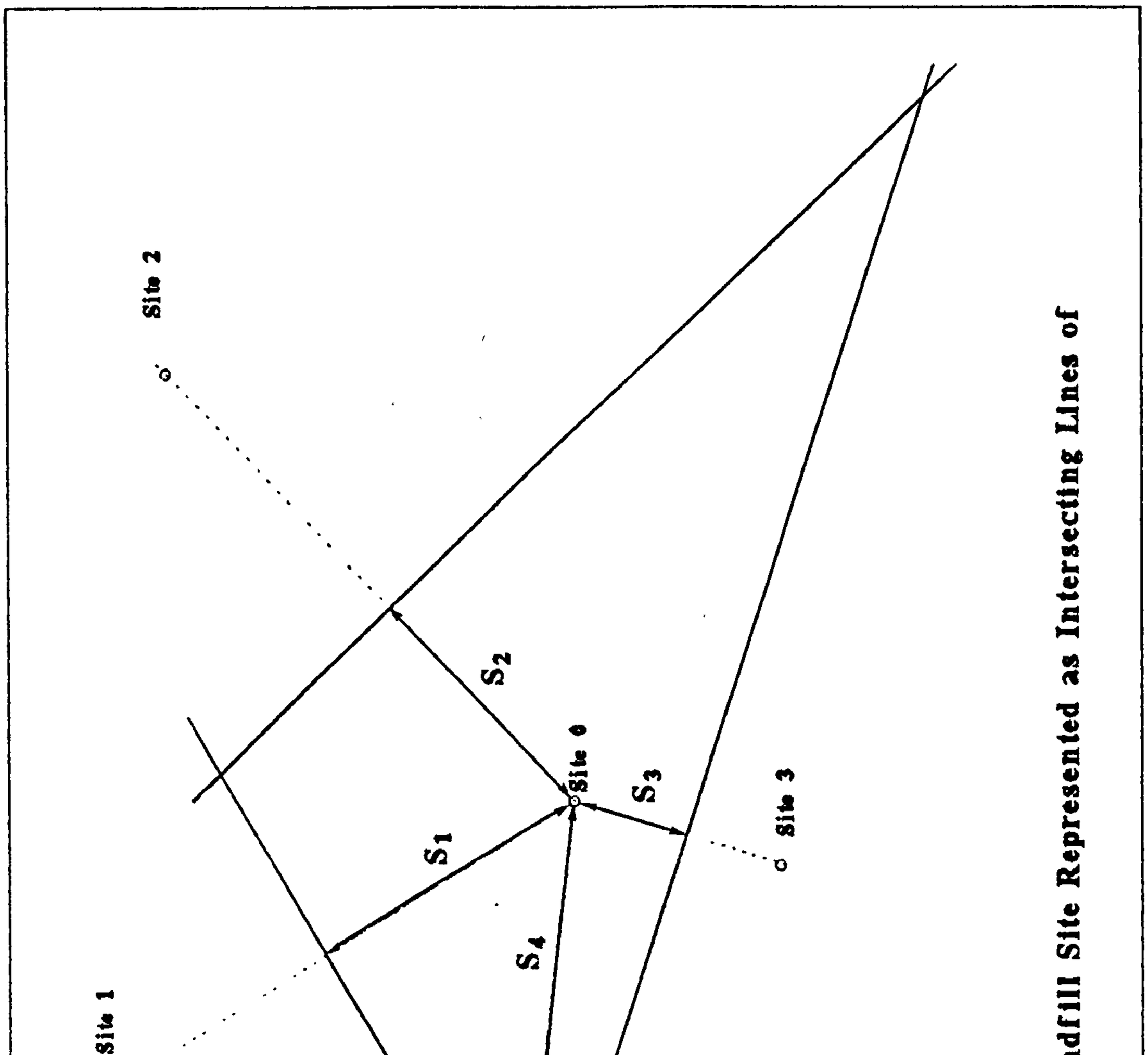


Fig 8.1: Catchment of a Landfill Site Represented as Intersecting Lines of Cost Indifference

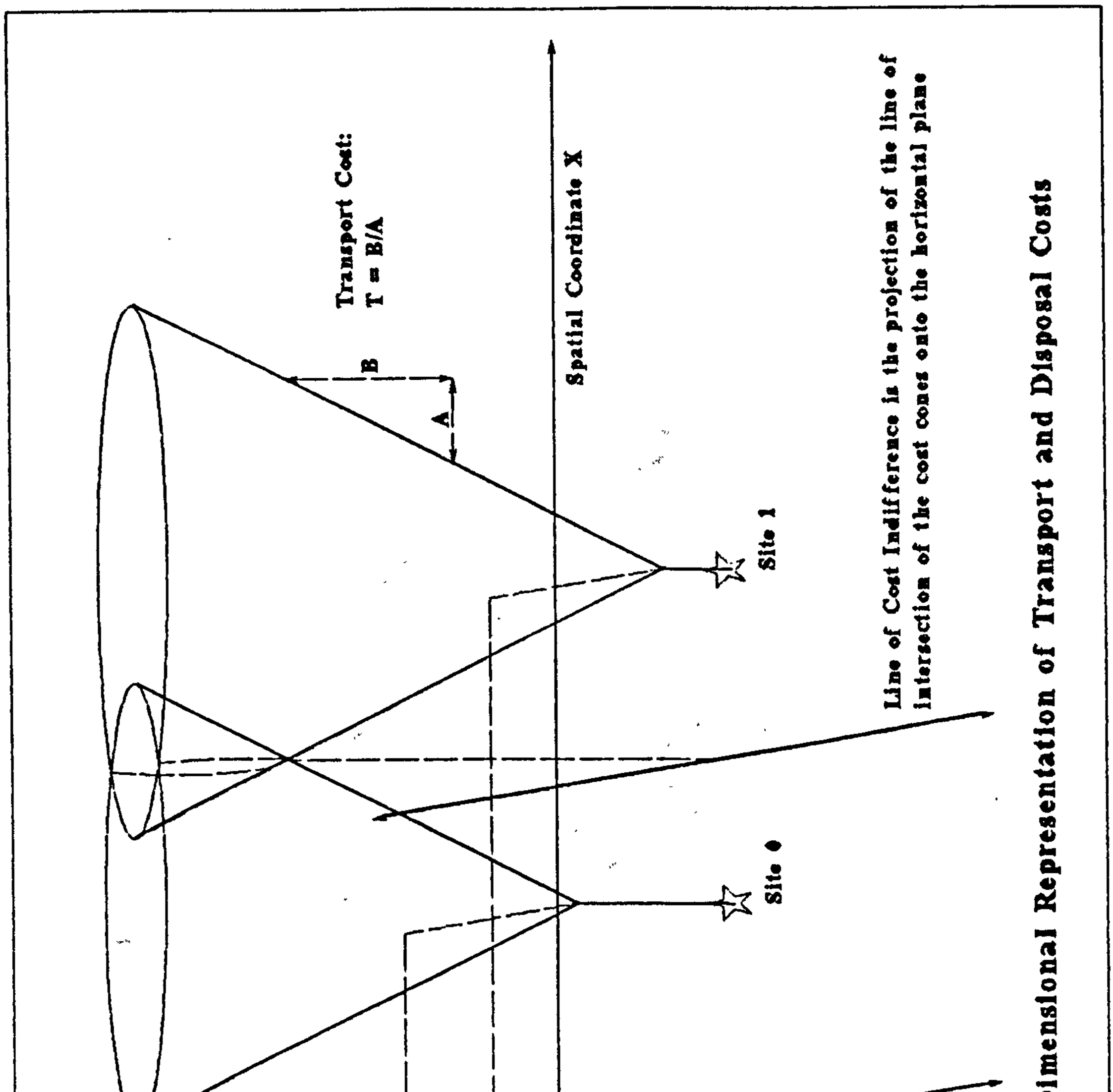


Fig 8.2: A Three Dimensional Representation of Transport and Disposal Costs

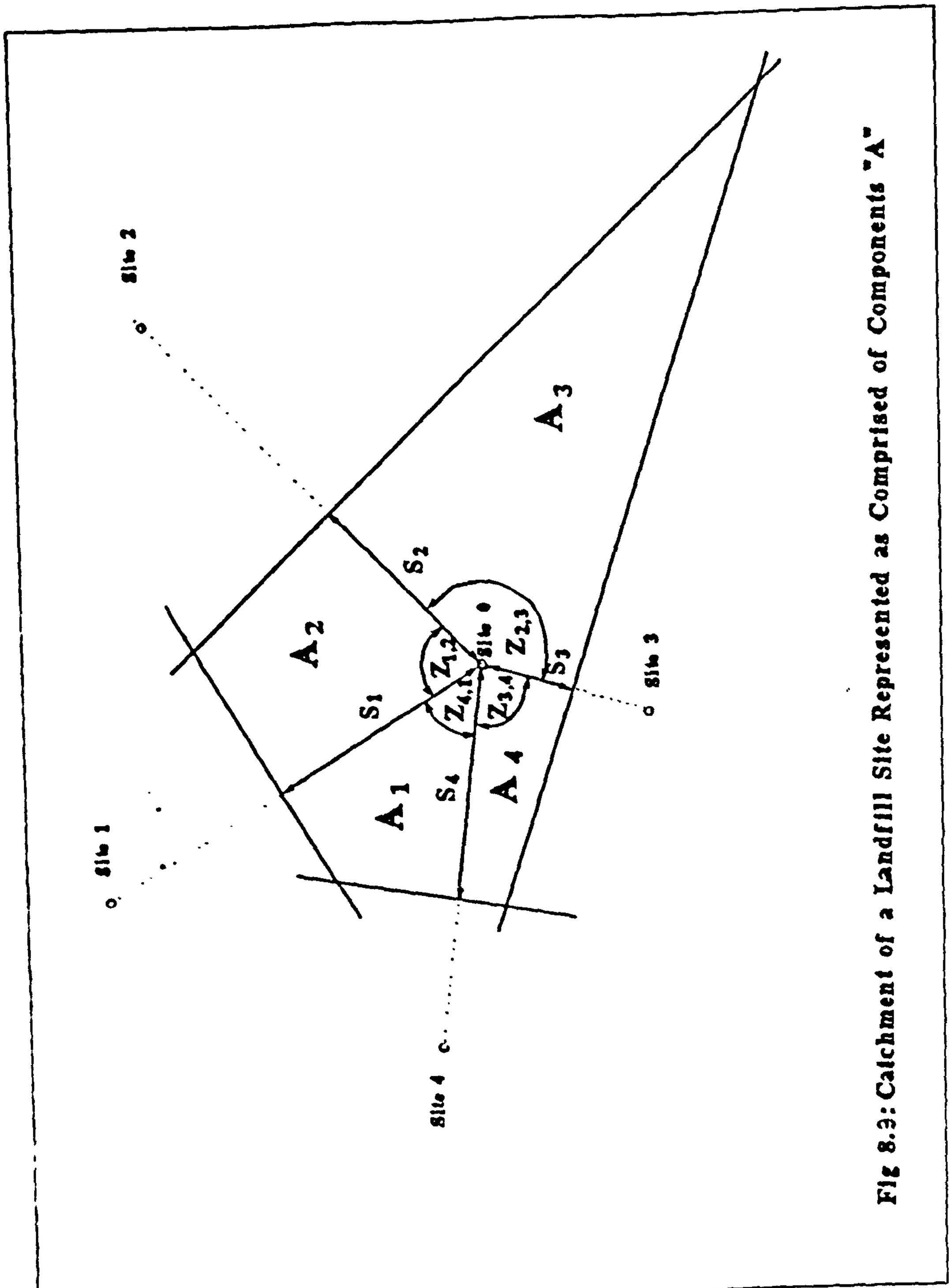


Fig 8.3: Catchment of a Landfill Site Represented as Comprised of Components "A"

Similarly area A_2 can be expressed in terms of; S_1, S_2, $Z_{1,2}$.

Equations 1 and 2 can be used to calculate catchment area (as modelled above) for Site 0 competing with other landfill sites if the following values are known:

Price charged at Site 0 (£'s per tonne of waste)

Prices charged at competing sites (£'s per tonne of waste)

Cost of transporting waste (£'s per tonne per mile)

Distance from Site 0 to competing sites

Bearing (direction) of competing sites from Site 0

8.3 Model Assumptions

The model presented relies on simple economic assumptions about the behaviour of Waste Hauliers. More complex cases of haulier behaviour could be modelled using more sophisticated techniques. However use of more sophisticated techniques should reflect more sophisticated behaviour by Waste Hauliers than that modelled. Unfortunately, attempts to interview Waste Hauliers on their pricing policy and selection of disposal facilities met with failure.

The following four assumptions are made for modelling catchment areas of landfill sites.

Assumption 1: Waste Hauliers seek to minimise the cost of transport and disposal for each trip they make.

Although the data used for the model consider factors such as vehicle speed and driver's wages, Assumption 1 does not take account of other reasons why Waste Hauliers seek to reduce the time taken for each trip. Some hauliers may seek to minimise the time taken for each trip even if the trips cost more since higher costs can be borne by their customers. The ability to perform more trips with a given amount of vehicles increases the number of customers one haulier can service without spending money on increasing the number of vehicles operated. This situation may occur because:

Demand for waste haulage is greater than supply capacity and haulage firms cannot afford the capital costs of increasing capacity.

Waste Hauliers prefer to pass on high costs to customers than to enter into competition with each other.

Attempts were made to interview Waste Hauliers. Of twelve hauliers contacted, none was willing to discuss their choice of waste disposal facilities or pricing policy.

Assumption 2: Each trip is from one customer to a landfill site.

Assumption 2 ignores all situations where hauliers perform multiple pick-ups prior to delivery at landfill. Some such cases involve short trips between customer locations compared with a longer trip to the landfill site. In these cases the extra distance involved is negligible. BCWM reported one case where a haulier travels from a depot very near to a competing landfill and makes pick-ups along a route which leads to the landfill selected for modelling. The haulier then makes a similar return journey and a second delivery to the competing site. Modelling such cases would involve gathering detailed information about the activities of hauliers which deliver to landfills in a given area.

Assumption 3: Distances from Waste Haulier depots to customer locations and from landfill sites to the next customer or back to a depot are negligible.

Any trip requires travel to customer locations and return from the landfill site. A full assessment of waste transport costs would involve location of haulier depots, location of customers and identification of routes used. However it may be reasonably assumed that there are as many favourable combinations of depots and routes for the modelled site as there are for competing sites.

Assumption 4: Distances by road are 1.26 times the straight line distance between any two locations.

The value "1.26" is the "airline / road factor" commonly used in traffic research. This factor is the average ratio of distance by road to direct distance between two points.

A more sophisticated model could include data on particular journey routes. Such an activity would be time consuming and would tailor the model to the transport infrastructure around one site only.

8.4 Acquiring Data for the Model

In consultation with BCWM it was decided that the model would be applied to a particular landfill site (owned by BCWM). BCWM identified other landfill sites considered as competing with this site on a map. They also provided published price lists for all sites concerned.

Data for transport costs was found in two sources;

"The Managers Guide to Distribution Costs" (FTA 1990)

An article published in NAWDC news titled "Where the money goes - transport costs analysed" (NAWDC 1990)

Data on transport costs per mile is summarised in Table 8.1.

Table 8.1: Transport Cost Estimates

Vehicle Type (GVW is Gross Vehicle Weight)	"Managers Guide" Cost Estimate (pence/mile) for three milages; Average	Higher	Lower	NAWDC Cost Estimate (pence/mile)	NAWDC Estimated Tonnage/Trip (Tonnes)
Box or Curtain Van 7.5 Tonnes GVW	91.39	78.54	124.30		
Box or Curtain Van 10-12 Tonne GVW	85.44	81.60	131.87		
Box or Curtain Van 12-14 Tonnes GVW	92.57	87.14	113.40		
Box or Curtain Van 17-17 Tonnes GVW	103.41	88.69	130.50		
Skip Vehicle				150	1.5
6 by 4 Roll-on-off				198	5.2
6 by 4 Front Loader				231	5.0
8 by 4 Rear Loader				263	7.3

The NAWDC article gave higher costs than those quoted because the article also accounts for profit (which is not done for the "Manager's Guide" data). The figures for profit (given in the NAWDC article) are already subtracted from the figures given in Table 8.1.

Both sources of data provide transport costs per vehicle mile rather than costs per tonne per mile.

The following sources of data were investigated to overcome this problem;

Weighbridge data from the selected landfill site (for a period of four days) was provided by BCWM which gives data concerning each delivery of waste, including; the laden weight of vehicles entering the site, vehicle registration numbers, the category of waste delivered and the unladen weight of vehicles leaving the site.

Waste transfer notes submitted to the selected landfill site over the course of two weeks (including the four days for which weighbridge data was supplied) were provided by BCWM. These notes provide a written description of waste delivered and some also provide a description of the vehicle used.

For skip loads of waste, waste transfer documents were compared with the weighbridge data using the following method.

Waste deliveries from the following categories of skip loads (used in weighbridge data) were analysed:

Category 02 (capacity 0-3 cu. yards)
Category 03 (capacity 3-10 cu. yards)
Category 04 (capacity 10-15 cu. yards)
Category 05 (capacity >15 cu. yards)

Weighbridge data also identified wastes fitting the following descriptions:

Cover Material

Hardcore

Transfer note descriptions were used to identify loads brought in on skip vehicles. Transfer notes also include written descriptions of waste from which it is possible to identify deliveries of:

Soils (including sand)

Rubble (including "builder's waste")

Other waste (including packaging, and "non-specific industrial" waste)

Each load delivered to the site in a skip was identified in the weighbridge data (by comparing vehicle registration numbers given on transfer notes with those given in weighbridge data). It was noticed that loads of soils and cover material

were of similar weight to each other and that loads of hardcore and rubble were of similar weight to each other. The average weight for different kinds of load is shown in Table 8.2.

Table 8.2: Average Weights (in tonnes) of Different Loads Delivered in Skips

NB: Sample size is given in parentheses below each entry with respect to waste types given.

	Skip Category			
Waste Type	02	03	04	05
Cover & Soils	4.08 (8 & 2)	6.04 (3 & 0)	N/A (0)	N/A (0)
Hardcore & Rubble	2.70 (12 & 8)	3.70 (7 & 3)	N/A (0)	6.19 (0 & 1)
Other	1.46 (22)	1.92 (7)	1.94 (5)	1.14 (5)

Comparing figures in Table 8.2 with NAWDC's estimate of load weight for skips (Table 8.1) suggests that NAWDC's estimate is based on haulage of "other" wastes.

It is unsurprising that smaller skips are used for soils and cover since the maximum load for a skip vehicle is 8 tonnes.

The low average weight for other wastes in skips could be due to larger skips being employed for the least dense wastes (such as packaging).

Based on these figures and using the NAWDC estimate for skip transport cost of £1.50 per mile, estimates of transport cost for various waste loads are shown in Table 8.3.

Table 8.3 Average Costs (per tonne per mile) for Different Waste Types Transported in Skips

Waste Type	Skip Category 02	03	04	05
Cover or Soils	37p	25p	N/A	N/A
Hardcore or Rubble	56p	41p	N/A	24p
Other	103p	78p	77p	132p

The model outlined in Section 8.2 also requires data for location of competing facilities and the prices charged by all facilities concerned.

BCWM identified the location of competing facilities on a map. The distance of each facility and its direction (measured in degrees from North as shown on a map) were measured relative to the landfill for which catchment area was to be modelled (hereafter refered to as "Site 0"). The location of these facilities is shown in Table 8.4.

Table 8.4 Location of Facilities Competing With Site 0

Site No.	Distance (miles)	Direction (degrees)
1	10.9	289
2	13.6	291
3	16.4	316
4	13.4	80

Sites 0 and 1 charge a set price for any deliveries in Categories 02, 03 and 04 regardless of load size and a price per tonne for wastes in other categories. Furthermore, these sites charge a minimum of £5.00 per delivery. Using figures for average load sizes given in Table 8.2 these figures can be approximated to prices per tonne. Other facilities charge a price per tonne. Site 4 charged less for builders waste (soils and rubble) than other waste. All sites offered discounts for cover or hardcore materials.

The prices charged by facilities are shown in Table 8.5.

Table 8.5: Price Data for Landfill Sites

Landfill Site	Load Type	Category	Price / Load	Price / Tonne
Sites 0 & 1	Soils	02	£13.00	£3.19
		03	£30.00	£4.97
	Rubble	02	£13.00	£4.81
		03	£30.00	£8.11
		05	N/A	£12.00
	Other	02	£13.00	£8.90
		03	£30.00	£15.63
		04	£39.00	£20.10
		05	N/A	£12.00
	Cover	02	£5.00	£1.23
		03	N/A	£1.00
	Hardcore	02	£5.00	£1.85
		03 & 05	N/A	-£1.50
Sites 2 & 3	Soils	02 & 03	N/A	£17.50
	Rubble	02, 03 & 05	N/A	£17.50
	Other	All	N/A	£17.50
	Cover	02 & 03	N/A	£1.00
	Hardcore	02, 03 & 05	N/A	£1.50
Site 4	Soils	02 & 03	N/A	£7.70
	Rubble	02, 03 & 05	N/A	£7.70
	Other	All	N/A	£15.50
	Cover	02 & 03	N/A	£0.70
	Hardcore	02, 03 & 05	N/A	£2.00

Note that Sites 0 and 1 pay Waste Hauliers £1.50 for delivering hardcore. This is represented as a negative price charged in Table 8.5.

The model presented in Section 8.3 was applied using a spreadsheet. In this case the model was adapted to account for a coastline to the South of Site 0. This geographic boundary limits catchment area regardless of the value of other variables. The Coast was modelled as a straight line by defining a dummy facility which charges the same price for all wastes as Site 0 and which is located "in the sea" at a point symmetric with Site 0's location and the line which approximates to the coastline. The model was used to calculate catchment areas for each type of load and to estimate the number of loads arising per square mile of catchment (using the data for number of loads of each type given in Table 8.2).

The spreadsheet was also used to output visual representation of the catchment area in each case.

The values determined are shown in Table 8.6.

Table 8.6: Model Catchment Areas of Site 0 for Different Load Types

Load Type	Skip Category	Catchment Area (square miles)	Skip loads arising per sq. mile
Soils	02	375	0.0897
	03	354	0.0479
Rubble	02	266	0.0389
	03	186	0.0218
	05	0	**Infinite**
Other	02	259	0.1165
	03	171	0.0808
	04	105	0.0699
	05	204	0.0342
Cover	02	149	0.0600
	03	154	0.0221
Hardcore	02	164	0.0897
	03	175	0.0479
	05	183	0

The "infinite" entry describes the model's determination of loads arising per square mile of Site 0's catchment area for rubble in Category 05 (greater than 15 cu. yard capacity) skips. This is due to the determination of zero catchment size for this type of load despite the occurrence of one such load in the data.

A number of reasons could account for this. For example the driver delivering the load may have been in a rush to make his next pick-up and so he took waste

to the nearest site despite the price charged. Whatever the reason, the data illustrates that "catchment area" is not as simple as the model suggests. It should be remembered that "catchment area" is an abstract concept. In reality, there are no lines of demarcation between landfill sites for different kinds of waste load which govern the behaviour of Waste Hauliers.

The results of running the model were represented visually on polar graphs (some examples are shown in Figs 8.4 to 8.6). These graphs show the modelled shape and size of Site 0's catchment for different kinds of load. Marketing staff at BCWM were asked to sketch the catchment of Site 0 on a map (based on their personal experience). These graphs derived above were found to be a good fit to BCWM's conception of Site 0's catchment in terms of shape. It was thought, however that the catchment for "other wastes" should be larger and that the catchment for "soils" should be smaller. This would seem to suggest that the model systematically exaggerates larger and smaller catchment areas. One of two factors would account for this;

> either the transport cost per tonne per mile is underestimated
>
> or Assumption 1 is not correct (if, for example, hauliers seek to reduce journey time despite higher costs, then catchment area boundaries would tend to be situated nearer to halfway between facilities than predicted by the model)

The catchment model in this case is more useful as a tool for approximating the elasticity of catchment area with respect to price charged at a landfill site than as an accurate description of the catchment of a particular site.

The catchment of Site 0 can be similarly modelled for any kind of waste load for which a transport cost per tonne per mile can be determined and for which prices per tonne can be determined for each competing site. Note that evaluating transport costs and prices may involve assumptions about the weight of loads involved. In this case an average load weight was assumed to be appropriate.

Although the model seems to exaggerate small and large catchment areas, it does serve as an approximating tool for determining catchment area and consequentially, the spatial density of wastes arising for different kinds of load.

The model does, generate fairly accurate results for skips carrying builders' rubble. The model was run to estimate catchment areas for various gate prices charged at Site 0 and various transport costs per tonne per mile for builders' rubble. Prices charged at competing sites were presumed to remain constant. Using £2 increments for the price charged per tonne at Site 0 and 20p increments for the cost per tonne per mile of transporting waste, a family of lines was generated as shown in Fig 8.7.

These results show that wastes incurring lower transport costs per tonne per mile are more sensitive to changes in price charged at landfill sites. Fig 8.7 is used in Chapter Nine to estimate change in landfill site throughput for a change in price charged for skips of builders' rubble.

Fig 8.4: Modelled Catchment Boundaries for Category 02 Skips Carrying Cover Material

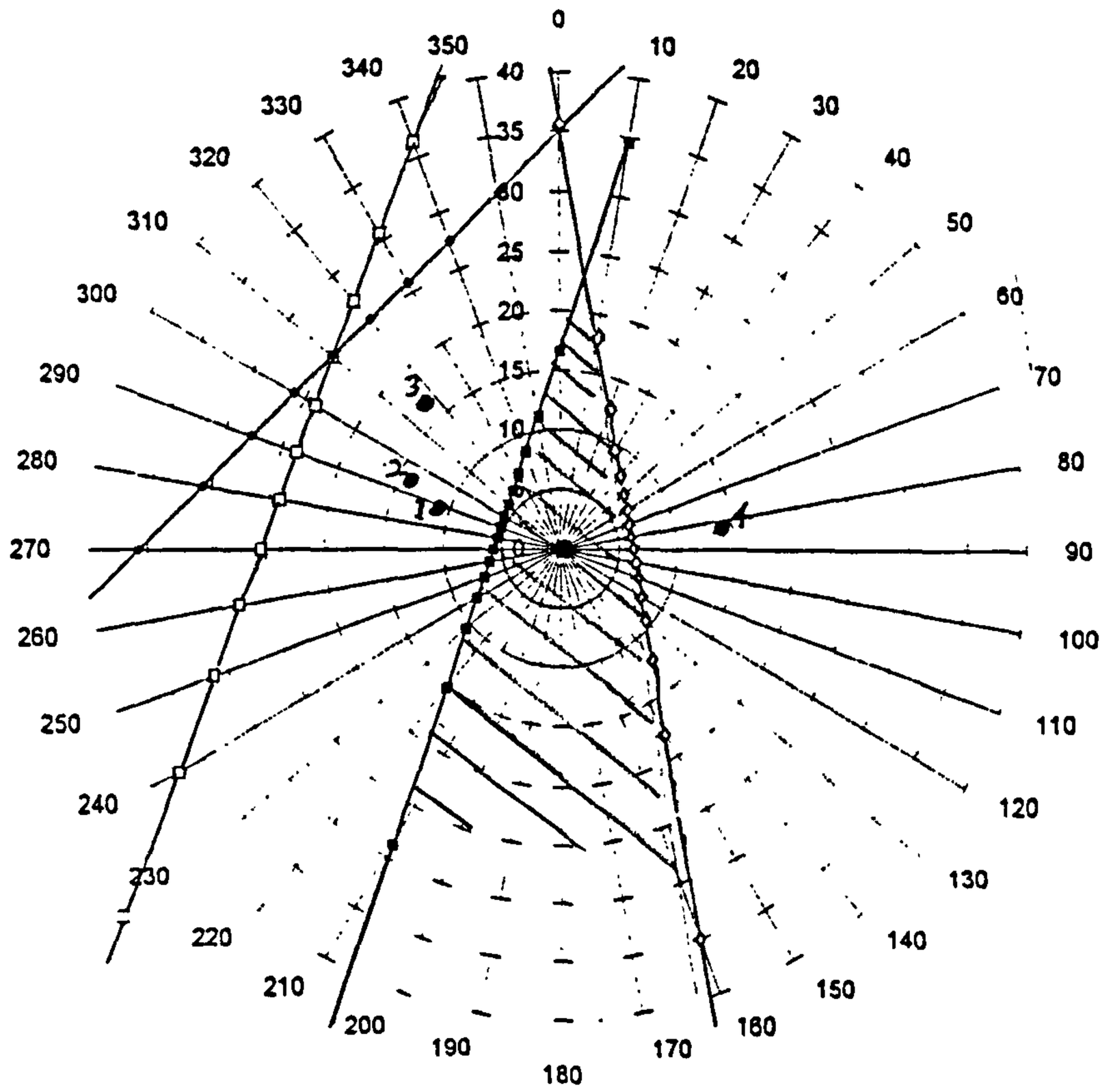


Fig 8.5: Modelled Catchment Boundaries for Category 02 Skips Carrying "Rubble"

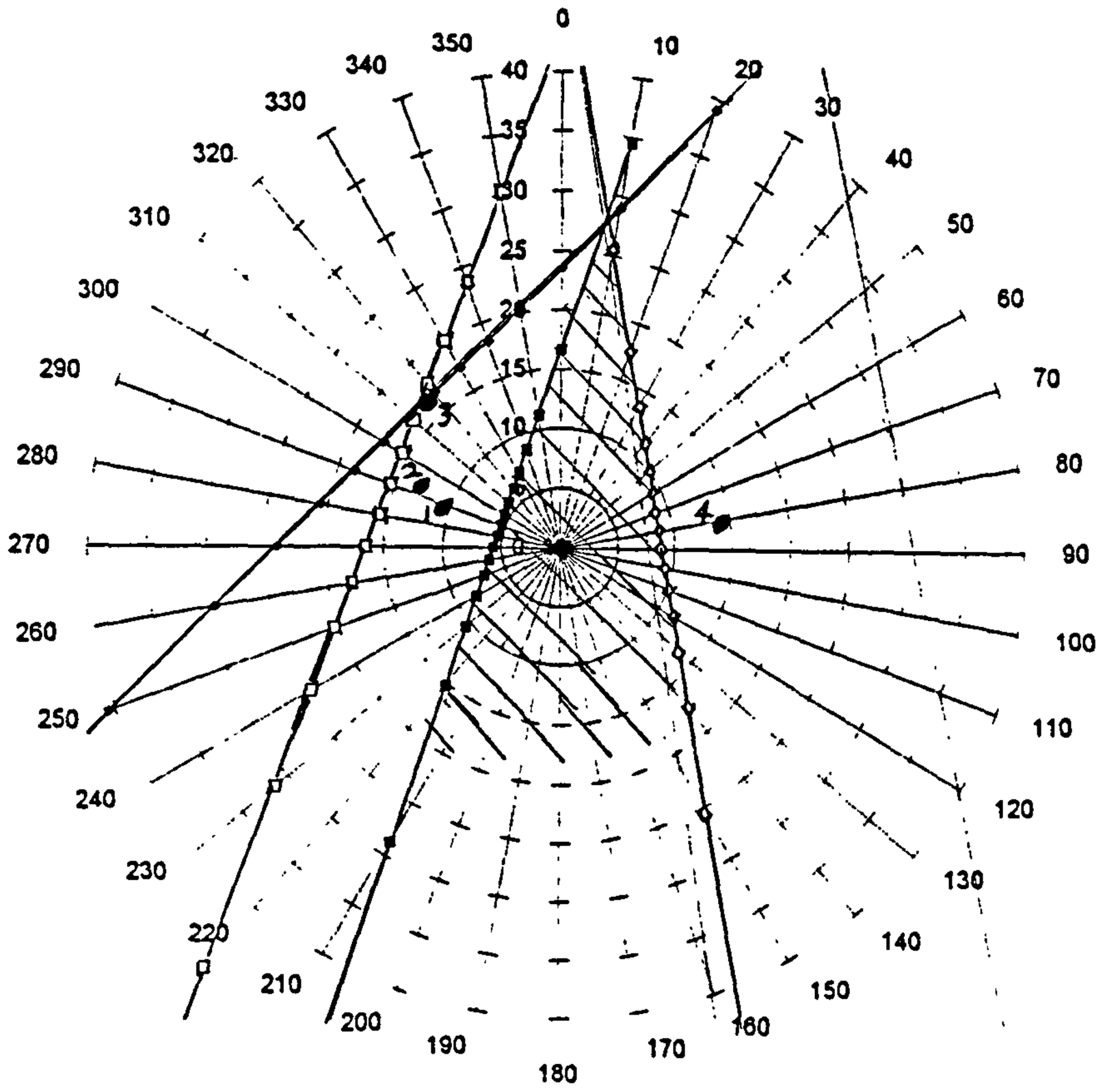


Fig 8.6: Modelled Catchment Boundaries for Category 02 Skips Carrying "Other" Wastes

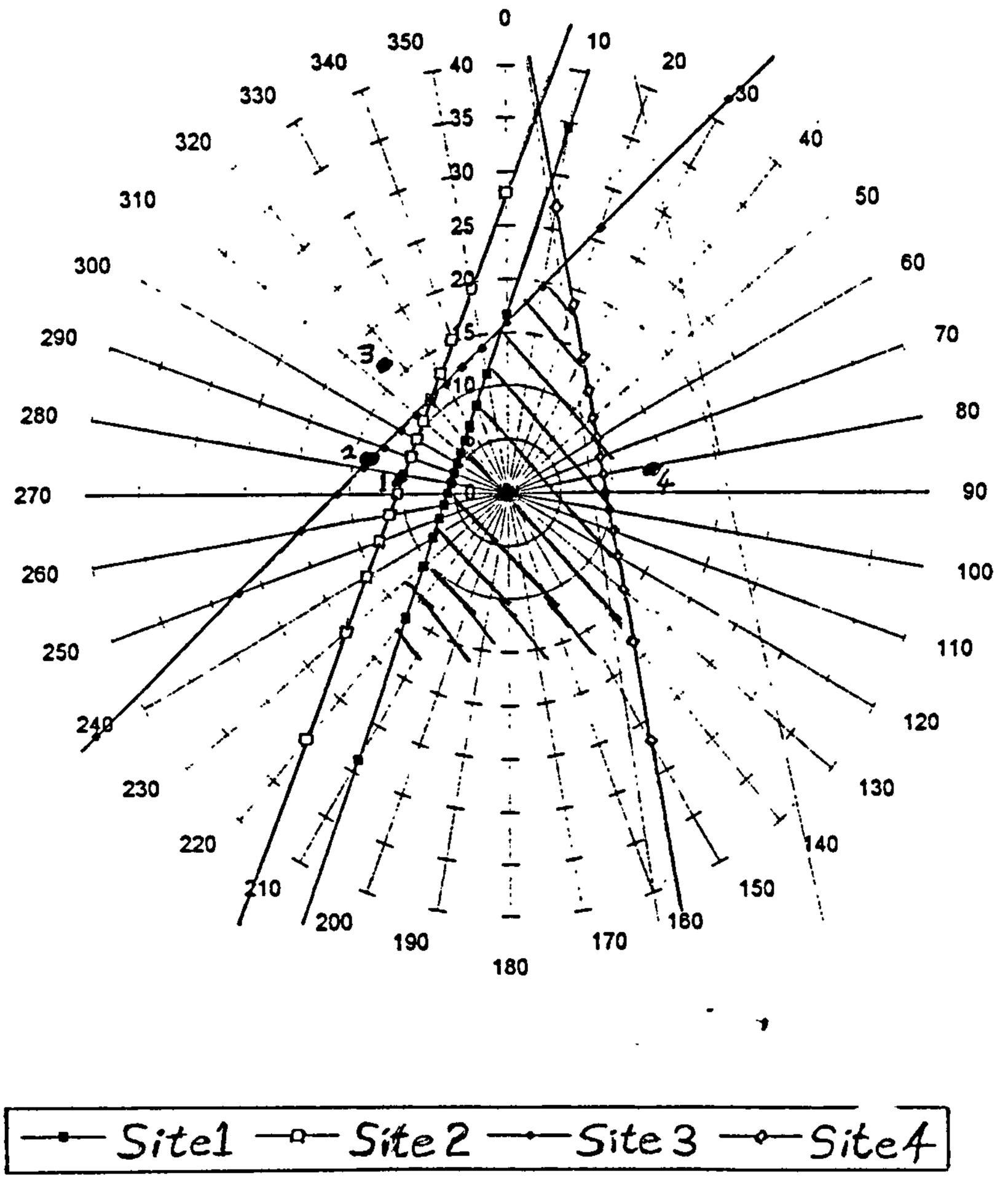
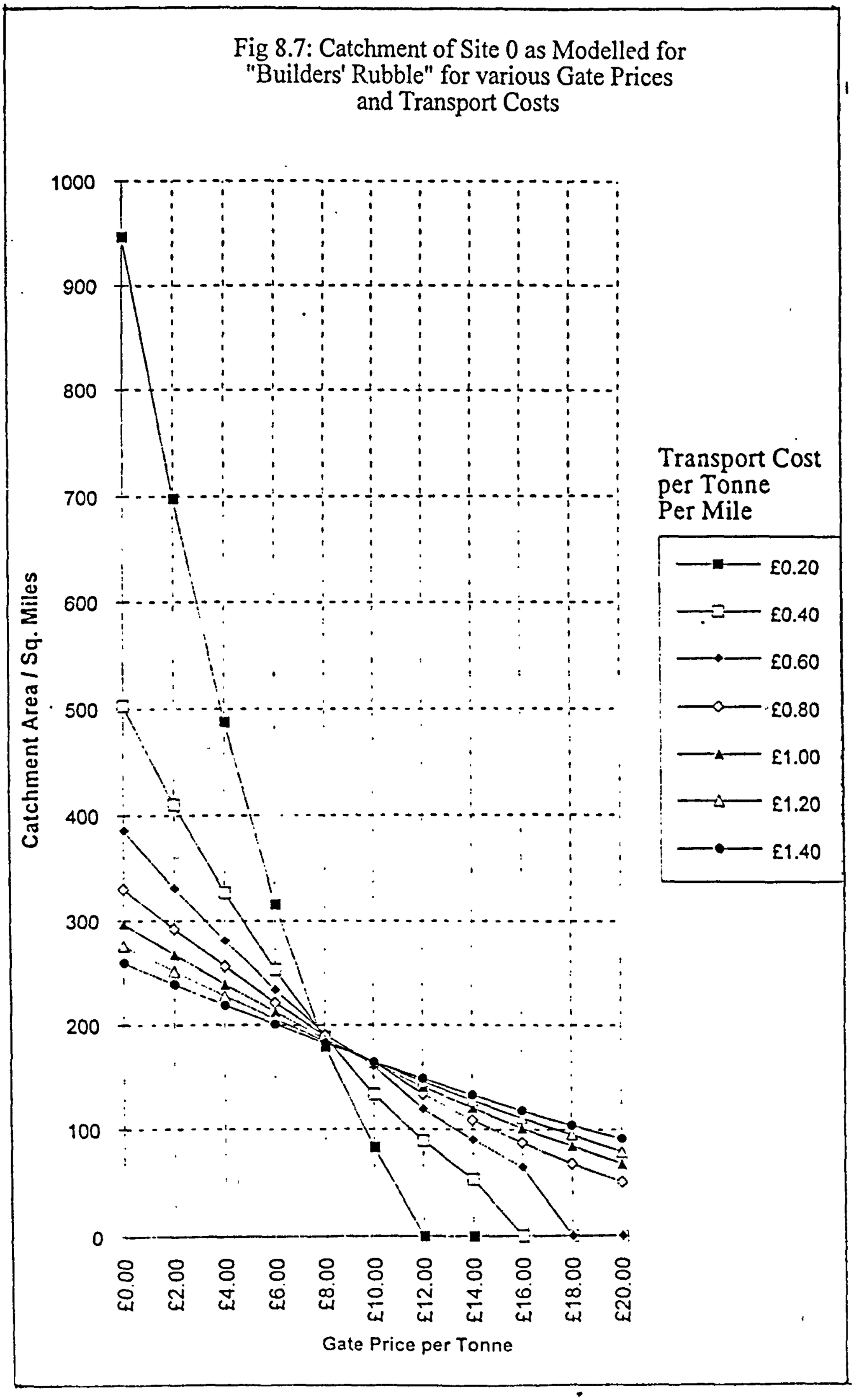


Fig 8.7: Catchment of Site 0 as Modelled for "Builders' Rubble" for various Gate Prices and Transport Costs



8.5 Qualitative Uses of The Model

In this section, two further applications of the model are considered:

Possible consequences for catchment of a waste facility due to source separation of wastes

Possible consequences for catchment of a waste facility due to changes in landfill pricing policy

Source separation of wastes is only likely if a waste facility requires waste to be separated prior to arrival at the facility. This may be required for some types of recycling activity. The model may be used to consider the catchment of such a facility contrasted with that for a facility which does not require waste to be separated.

In this case, BCWM were more interested in generally useful information rather than in the analysis of particular recycling options.

Consider two forms of source separation of wastes which are referred to below as **Scenario 1** and **Scenario 2.**

Scenario 1

To achieve streaming at source, an additional container can be used which is identical to those already employed to store wastes.

Assume that the separated waste has the same density as for wastes otherwise removed. Hence the container load is of the same weight and incurs the same cost of transport per tonne per mile as wastes otherwise removed.

The Waste Producer appreciates a higher cost of waste storage due to the additional container used. Assume also that this cost can be represented as a fixed price per tonne of waste removed.

In this case, the Waste Producer only benefits under two conditions;

if the destination for separated materials is nearer than that for other wastes

or

if the destination for separate materials charges less to accept them than is charged for other wastes

In terms of the catchment model, the additional cost for storage can be represented as an additional cost per tonne of waste appreciated for wastes sent to the facility which requires source separation. Considering Fig 8.2, this may be represented as an increase in the vertical displacement of the cost cone (above that due to price charged at the facility per tonne of separated wastes).

Consider an established waste management facility which requires particular wastes to be separated. The effect on catchment for loads separated according

to Scenario 1 is a reduction in area unless a reduced price is offered to compensate for increased storage costs per tonne of separated waste appreciated by customers.

Scenario 2

If the Waste Producer cannot or will not increase overall storage capacity, then source separation is only possible by segregating existing capacity. Ideally, the ratio of separation should match the production ratio for each waste stream. Waste from each stream must be removed in smaller loads for each stored stream and removed as frequently as waste loads were previously removed.

Removal of smaller loads suggests an increased cost per tonne per mile for the wastes. In terms of Fig 8.2, this may be represented as an increase in the gradient of the sides of the cost cone located above the facility requiring separated loads. Whilst two cones with the same gradient for their sides intersect along a curve in the vertical plane this is not so if one cone has a different gradient. The line of intersection becomes a closed loop as represented in Fig 8.8. The projection of this loop onto the horizontal plane is not immediately apparent.

A modified version of the spreadsheet model was used to plot "points of cost indifference" between competing facilities in polar coordinates at ten degree increments. Transport costs to the central facility were biased using a multiplying factor called "gamma". It was found that the shape of the lines of indifference became "cardioids" (circles with an indentation similar to a rounded heart or a plump kidney shape) as shown in Fig 8.9. Modelled catchment areas for the central site have concave or convex boundaries as shown in Figs 8.10 to 8.13.

Consider an established waste management facility which requires particular wastes to be separated. The effect on catchment for loads separated according to Scenario 2 is a reduction in area and a change in shape. Reduced prices charged by the facility could increase the catchment size. However, restoring the shape of the catchment area would require some form of compensation which accounted for increased transport costs per tonne per mile which would be difficult to assess.

The two scenarios presented are not exhaustive of all the possible ways in which customers could appreciate increased costs due to source separation of wastes. However these scenarios exploit the two key variables which are likely to be influenced by the source separation and which the model employs. Any increased costs appreciated by Waste Producers that can be represented as an increased cost per tonne of waste produced and/or as an increased cost per tonne of waste produced per mile travelled to the waste facility can be modelled as a combination of the two scenarios outlined above.

Identifying such costs and representing them in such a fashion would require further research into the costs of waste storage and transport. Such research would need to focus on a particular recycling operation which required source separation so that particular Waste Producers could be targeted to asses likely cost increases.

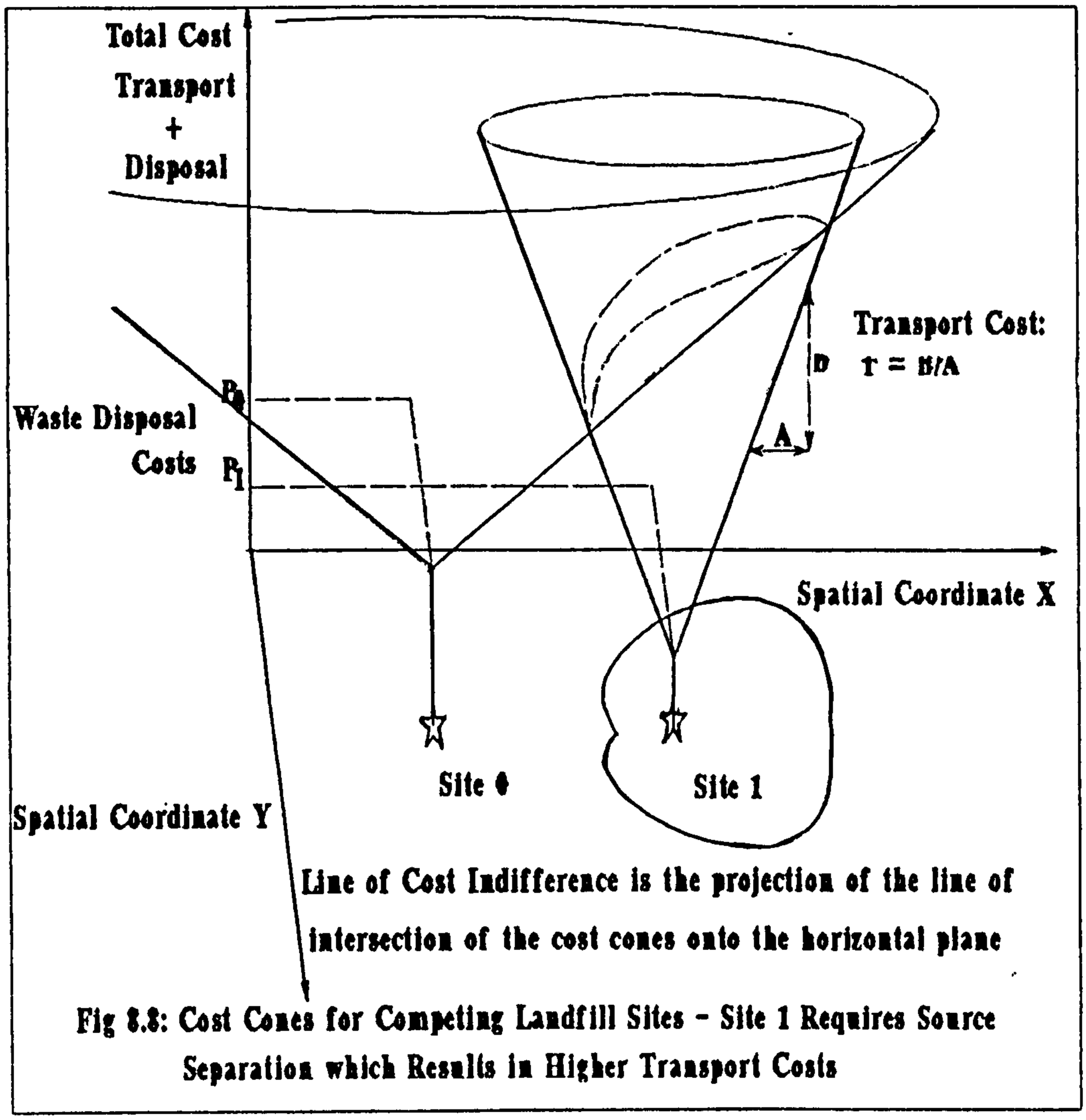


Fig 8.8: Cost Cones for Competing Landfill Sites - Site 1 Requires Source Separation which Results in Higher Transport Costs

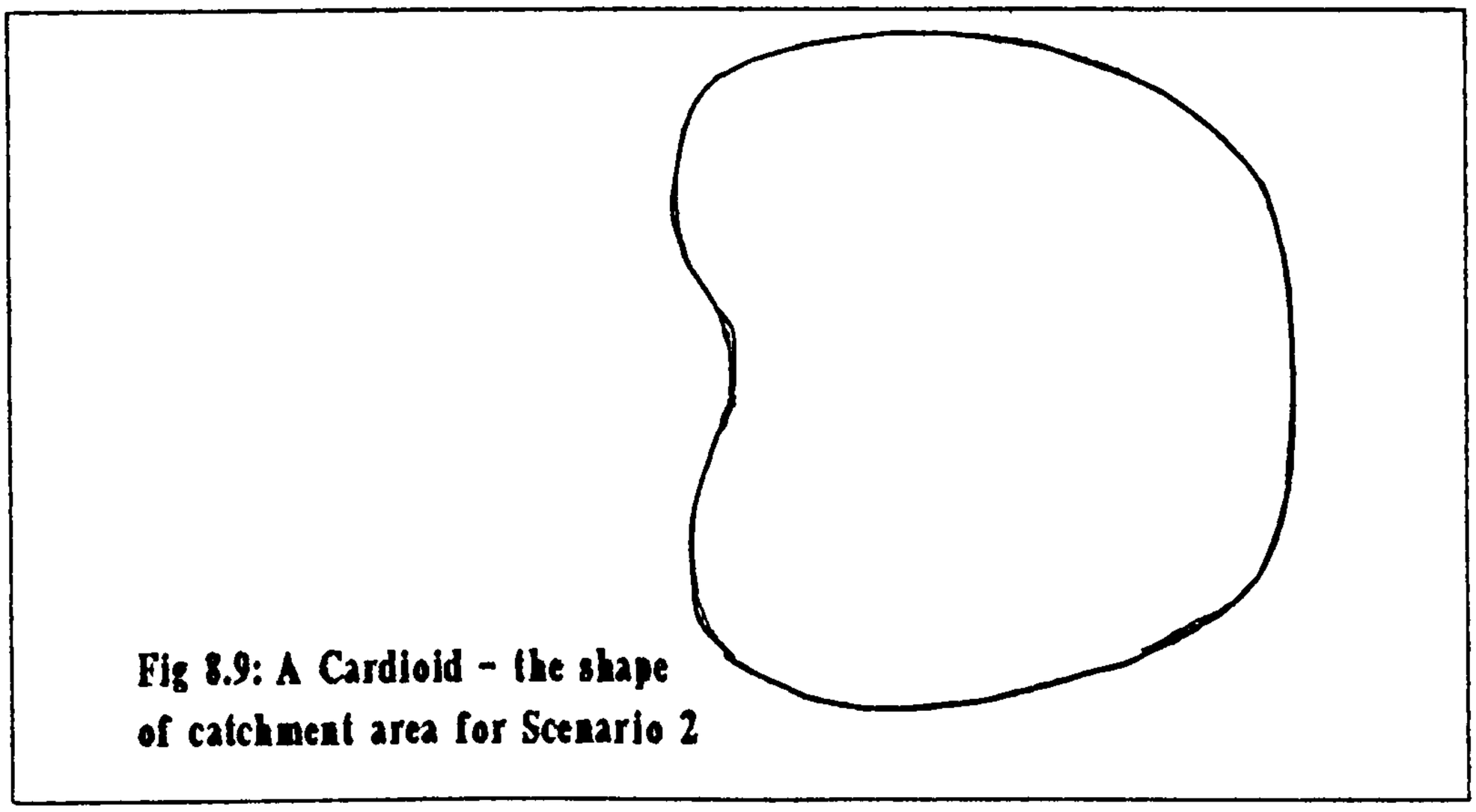


Fig 8.9: A Cardioid - the shape of catchment area for Scenario 2

Fig 8.10: Modelled Catchment Boundaries for a Central Site Charging £0.80 per Tonne whilst Four Competing Sites Charge £13.50 per Tonne for Waste which Costs £1 per Tonne per Mile to Transport

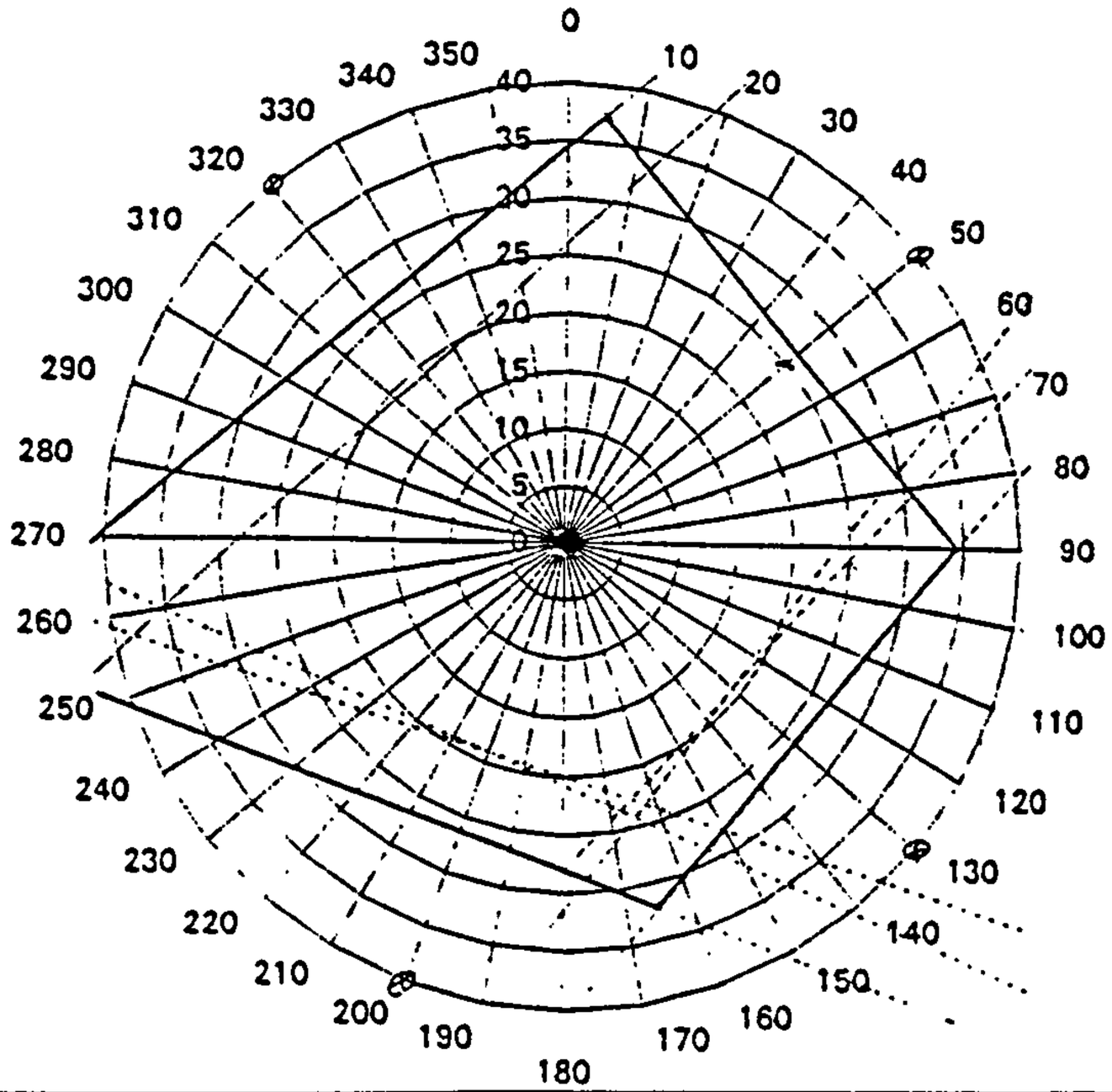


Fig 8.11: Modelled Catchment as per Fig 8.10 Except Waste Delivered to the Central Site Costs £1.20 per Tonne per Mile to Transport due to source separation

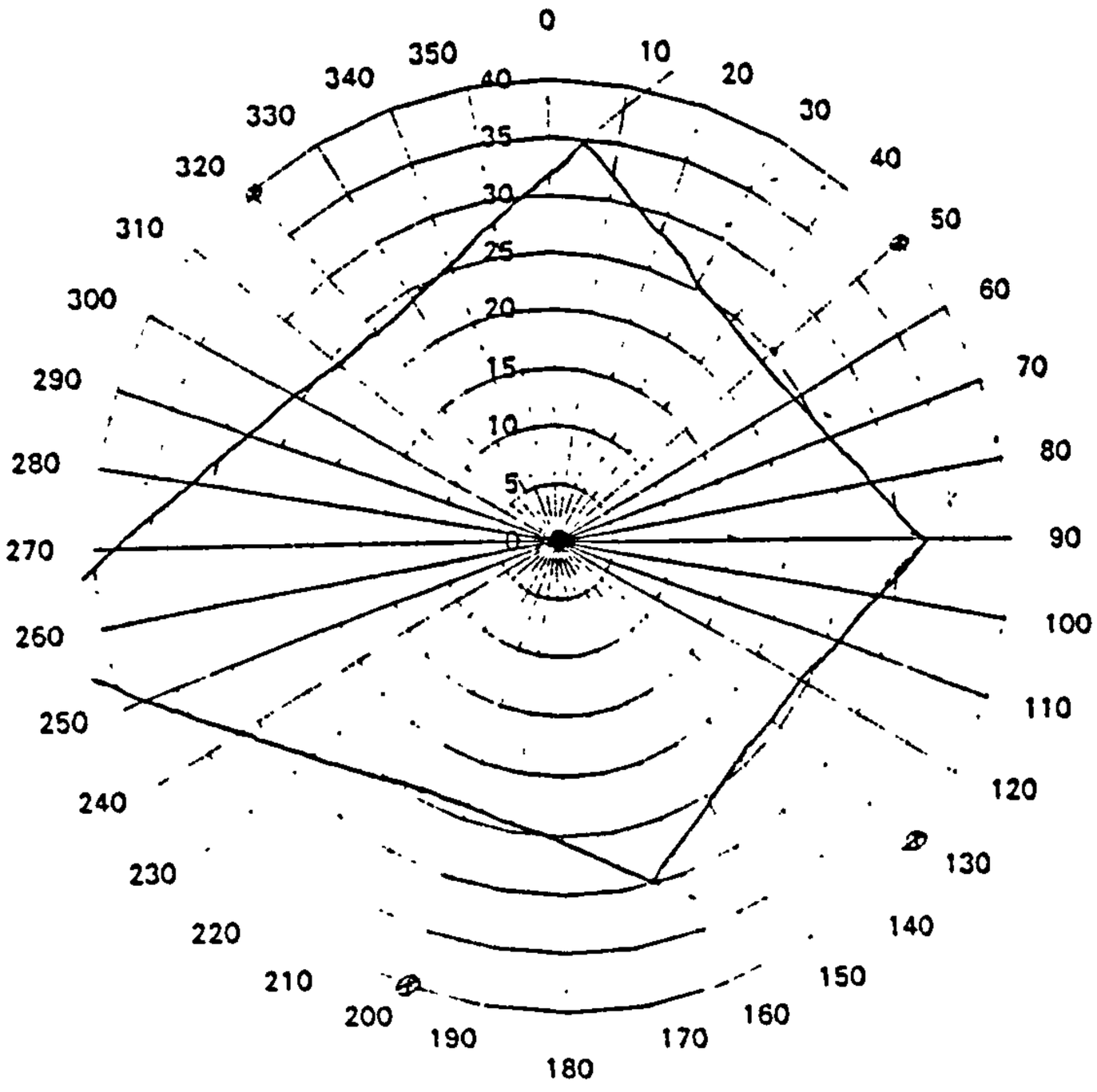


Fig 8.12: Modelled Catchment as per Fig 8.10 Except Waste Delivered to the Central Site Costs £1.50 per Tonne per Mile to Transport due to source separation

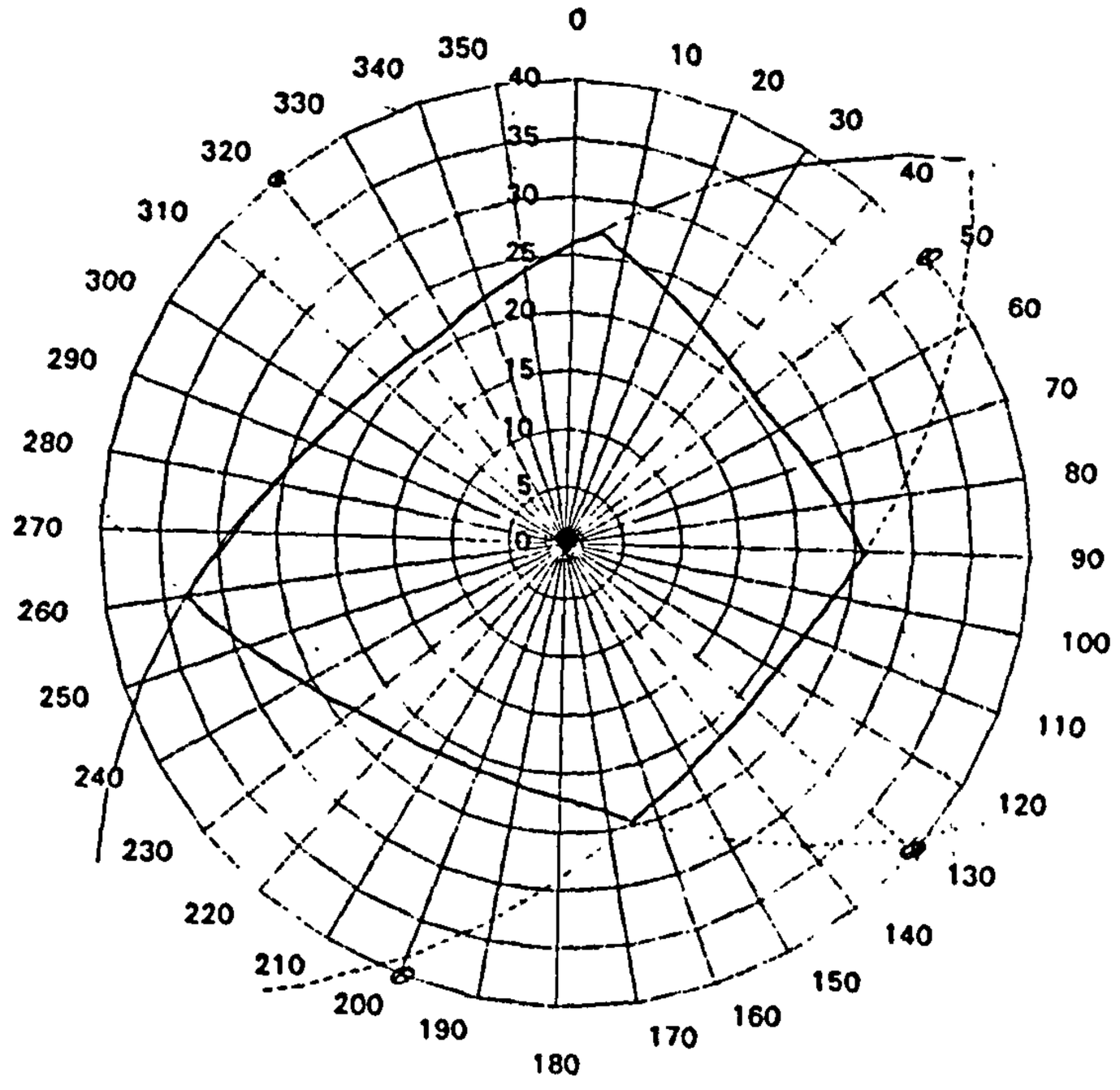
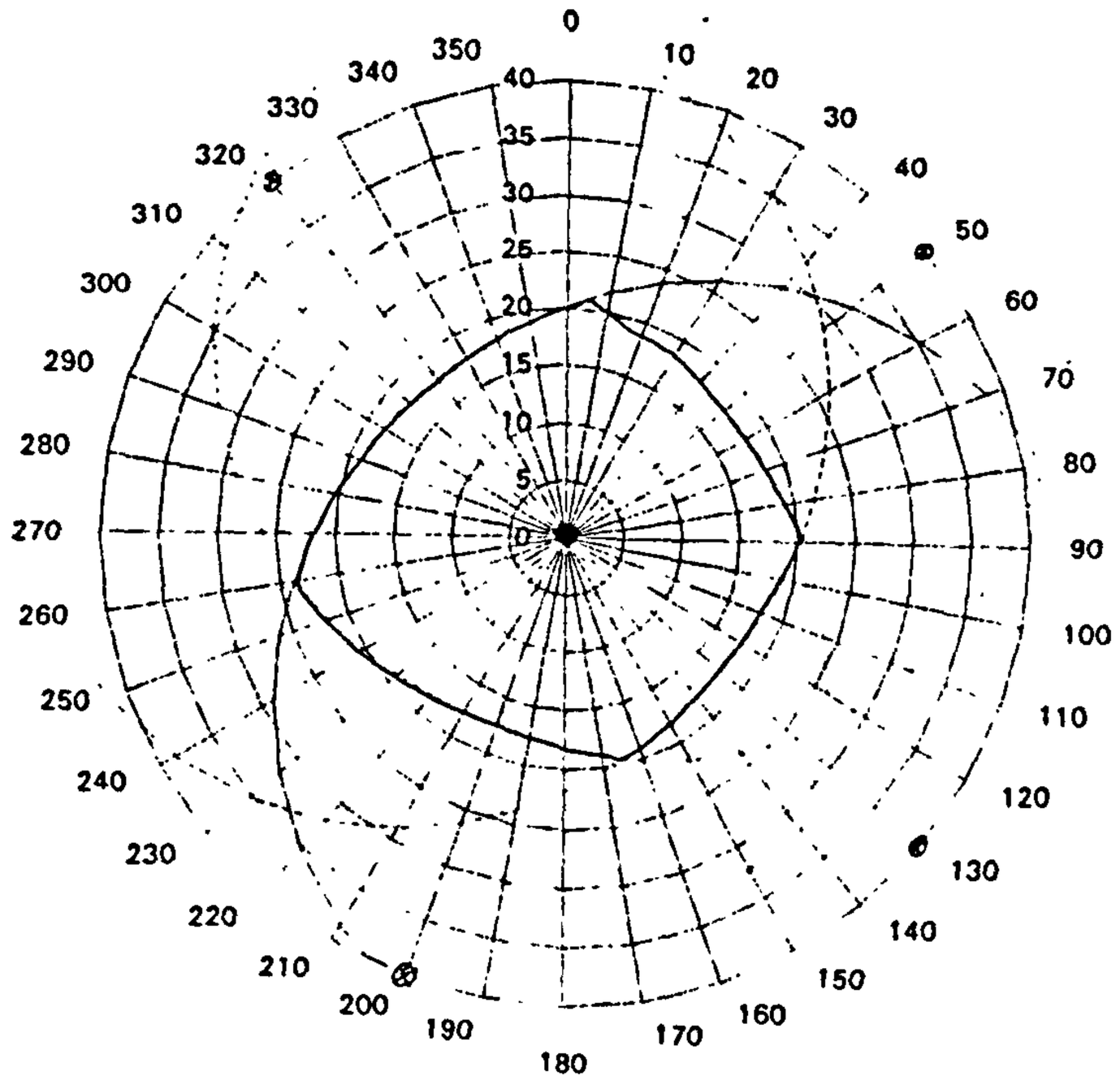


Fig 8.13: Modelled Catchment as per Fig 8.10 Except Waste Delivered to the Central Site Costs £2 per Tonne per Mile to Transport due to source separation



The model can also be used to consider ways to change pricing policy in order to increase the catchment area of existing landfill sites. Prices could be increased for deliveries of waste from sources near to a landfill site and decreased for deliveries of waste from sources further away. Local customers would still not be able to afford to use distant competing sites. Increased revenue from these customers could be used to subsidise prices charged to customers attracted from competing sites.

Some Waste Managers who operate their own haulage service effectively operate such a policy by charging a flat rate per tonne of waste for haulage and disposal, for customers in a given area.

This flat rate charging policy can be represented by considering the cost cone of a facility essentially transformed into a flat plane parallel with the horizontal plane and vertically displaced from the horizontal according to the flat rate charged. This is shown in Fig 8.14 and can clearly be seen to increase catchment size.

Being able to represent this phenomena with the model shows that the model could be used to analyse likely increases in business that could be achieved for different flat rate prices. However, the model does not demonstrate how a firm with no involvement in transport could implement such a policy.

Hauliers have no legal obligation to provide information on waste sources. Even if information could be obtained, there would be difficulty applying the policy to hauliers routing wastes via transfer stations or to hauliers performing multiple pick-ups on route.

That landfill operators involved in haulage can exploit opportunities which exploit flat rate pricing is clearly cause for concern for companies who do not. However, it should be noted that if all landfill operators followed suit then any advantage would be lost. Waste Hauliers may however, respond to the challenge of competition from landfill operators by finding ways to reduce their haulage prices. This would reduce the advantage for firms able to implement flat rate pricing policy.

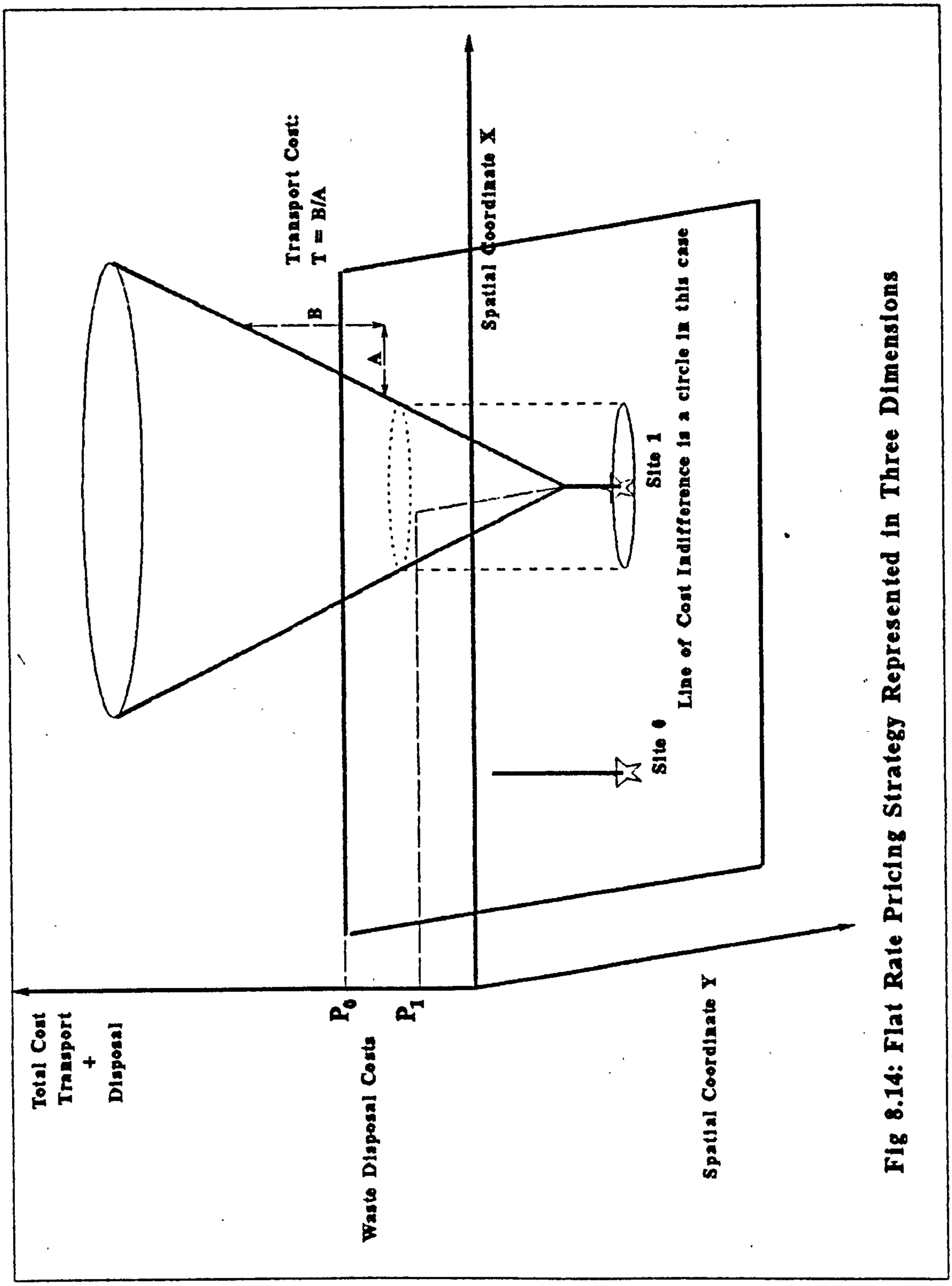


Fig 8.14: Flat Rate Pricing Strategy Represented in Three Dimensions

8.6 Conclusions

The catchment model developed provides estimates of landfill catchment size. The model may also be used to generate families of lines for catchment area under varying conditions of transport costs to one landfill if the prices charged at competing sites are known. The information generated for skip loads of construction waste is used in Chapter Nine to represent possible effects of price changes for the viability of a particular recycling operation.

Landfill catchment is an abstract concept which can only ever be modelled approximately. In the absence of complete data for the sources of wastes sent to landfill sites, the best source of evidence to support the model is the opinion of Waste Managers whose concern is the business of landfill. That the model exaggerates large and small catchment sizes seems to suggest that initial data underestimates transport costs or that Waste Hauliers prefer to use nearer landfill sites even if higher prices charged are not compensated for by proximity. Although hauliers were not willing to comment on this possibility, it is commonly thought in the waste management and construction sectors that construction waste hauliers are unsophisticated in their selection of routes and destinations.

If Waste Managers develop more sophisticated pricing regimes to reflect different costs of managing different kinds of waste (due to implementation of a recycling option or simply because some kinds of waste are easier to handle) they should not expect the full impact of such costs to be represented to Waste Producers. If Waste Hauliers tend to use local waste disposal facilities then Waste Producers are unlikely to appreciate much choice regarding waste management services. Comparison of model runs with BCWM's conception of landfill catchment suggests that hauliers do not always seek to minimise the total cost of disposal and transport for each trip. For example, Waste Managers may consider that packaging waste (or compressible waste from construction sites) takes up a lot of space in landfill sites and that they should charge more for such waste. However, packaging waste is usually transported in large vehicles which may yield a low transport cost (compared with skip waste say). In this case, a change of price may result in more lost business than a similar change of price for wastes that are more costly to transport. Conversely, separated packaging waste may provide a good source of materials for incineration or recycling. Operators of such facilities may expect better returns (in terms of volume of throughput) on price reductions if packaging waste is transported in compression vehicles to reduce transport costs than if packaging waste is transported loosely packed in smaller vehicles.

Wastes such as abated pollutants must be well contained in transit. Such wastes require higher standards of containment (perhaps in a tanker if liquid wastes are involved) and may be expensive to transport (see costs per for tankers in NAWDC 1990). The catchment model suggests that increased prices for more expensive wastes would not significantly reduce sales. The benefit to Waste Producers of a location near to a landfill site is not guaranteed. New pricing policies may negate such benefits. By contrast benefits may emerge for Waste Producers located about halfway between competing landfill sites (as far away from any site as possible) since they can exploit competitive prices offered to attract customers from one site to another. In Chapter Nine, the particular option to recycle construction waste at a landfill site is investigated. This investigation presumes that construction waste arrives for disposal in skip loads and includes consideration of different landfill prices for skip waste than those currently charged by using information generated by the catchment model (Fig 8.7) to estimate likely changes in throughput.

CHAPTER NINE

An Economic Assessment of Recycling at Landfill Sites.

9.1 Introduction

Waste Managers are well positioned to exploit recycling opportunities because:

> Waste Managers can licence recycling facilities as waste management facilities rather than production processes. Licensing requirements are strict for waste management operations, but benefits of recycling appreciated at a regional level seem to be more easily accounted for in the planning context of Waste Regulation Authorities than in the context of "ring fenced" regulation applied to production processes (see p.148).
>
> The majority of waste management firms are well resourced, progressive firms used to considering environmental issues during planning stages of developments.
>
> Waste Managers appreciate relative costs and benefits associated with different kinds of waste in disposal operations (such costs and benefits may not be represented to Waste Producers by Waste Hauliers). Hence, Waste Managers can identify potential benefits of alternative practices such as recycling.

However, in the absence of mandatory requirements, Waste Managers do not seek to recycle waste unless there is some financial benefit for them from doing so. In this chapter, one option to recycle construction waste at a landfill site is considered using cost benefit analysis. The method used enables consideration of circumstances which influence the viability of the recycling option.

The particular option to recycle construction waste arising in skip loads is analysed. This option is of particular interest to Blue Circle Waste Management Ltd (BCWM) because the majority of recycled materials can be used as cover materials and hardcore on landfill sites, presenting internal benefits. These materials are usually imported to landfill sites by offering price incentives to Waste Hauliers.

In Chapter Seven, it was shown that price incentives are not always perceived by Waste Producers in the construction sector. Source separation is only pursued on the basis of benefits of using larger vehicles for waste removal. Source separation of construction wastes is also limited by the ability of construction firms to manage multiple waste streams on sites (by policing their Sub-Contractors) and by vehicle access restrictions imposed locally.

Waste Hauliers play an key role in determining destinations for construction waste. In Chapter Eight effects of price charged on volume of waste attracted is modelled for a given landfill site. Estimates derived from this modelling activity are used in this chapter to consider how price changes could influence the viability of the recycling option.

The proposed recycling activity is based on a technique implemented at a small waste transfer station. That this company already recycles skip loads of waste (the majority of which are from construction sources) demonstrates that recyclable materials are present in the established construction waste stream. This operation is described in Section 9.2.

In Section 9.3 a method for assessing costs and benefits for Waste Managers of employing a similar technique at landfill sites is presented. This method is designed to address the question:

> Under what conditions is it preferable to invest in recycling technology for use at landfill sites rather than to continue landfilling wastes without pre-treatment?

By "conditions", the question refers to values of variables employed in the equations presented in Section 9.3. Estimates of these variables were available from BCWM, except for the variables of capital and operating costs for the recycling operation. The method presented in Section 9.3 shows that for given values of other variables, a linear relationship between the cost variables for recycling can be modelled.

In Section 9.4, a calculating model is presented that employs the method of Section 9.3. This model was applied incorporating data supplied by BCWM to calculate conditions (in terms of fixed and operating costs of the recycling operation) under which recycling is preferable. The model was run for different values of certain variables. The results of these runs are analysed in Section 9.5 in terms of other conditions which influence the recycling option (such as alternative prices charged for skips of builders waste).

In Sections 9.6 to 9.8, the findings of this modelling exercise are considered in a more general context by identifying findings that are pertinent to other forms of recycling and alternative options for waste disposal.

9.2 The Recycling Operation

The particular operation considered here is based on an operation conducted at a transfer station located within two miles of one of the landfill site for which catchment area was modelled ("Site 0" in Section 8.4). The transfer station exclusively accepts deliveries of open topped skips and derelict cars (for scrapping). Transfer stations usually receive materials in small loads to be bulked into larger loads to reduce transport costs. However, this transport station is located near to the final destination for the majority of waste loads received and it is operated to reduce waste volumes by recycling rather than to reduce unit transport costs.

The transfer station was visited and the owner interviewed in June 1993. Copies were also made of weighbridge data for the station.

The owner provided a guided tour of the site and the recycling operation in particular. The owner has only recycled material in the way described below for the last two years. However he has always sought to reduce the volume of material classified as "waste" leaving the site. The following materials are separated manually at the site:

From derelict cars;

Batteries

Tyres

Wiring

Plastic dashboards and fittings

From skips;

Metal objects

Plastic pipes

Any items desired by waste handlers

These items (and car bodies) are stored on site for removal to separate destinations.

Prior to the introduction of the new recycling operation, the remaining waste was burnt in the open to reduce volume. In 1989, the Local Council insisted that the practice of burning waste was stopped. By August 1992, a mechanical operation was being used to process residual wastes. A diagram of the plant employed is shown Fig 9.1. The operation is conducted as follows:

Skips carrying builder's waste are emptied into one of the "Sorting Bays."

Two operatives manually sort through the waste to remove valuable objects (eg. metals) and objects which may foul the "Crusher" (eg mattresses).

Another operative then uses a bulldozer to compress the waste against the end wall of the "Sorting Bay."

Meanwhile, another operative uses the "Grabbing Crane" (a crane fitted with a mechanical grabbing claw) to lift compressed materials and deposit them in the "Crusher." This operative can also stop and start the "Crusher."

The "Crusher" deposits broken down material onto "Conveyor 1" which passes under a "Sweeping Magnet". The "Sweeping Magnet" is a series of magnetic bars positioned on a belt which sweeps across "Conveyor 1" and then passes over the "Removing Bar" positioned over a skip. The magnets pick up metal objects which are then dragged of the magnets by the "Removing Bar" to fall into the skip. Residual waste on "Conveyor 1" is then deposited on the "Mechanised Screener".

The "Mechanised Screener" consists of revolving cylinders which are separated to allow fine materials to fall between them onto "Conveyor 2" and which have rough surfaces that continue moving waste onto "Conveyor 3."

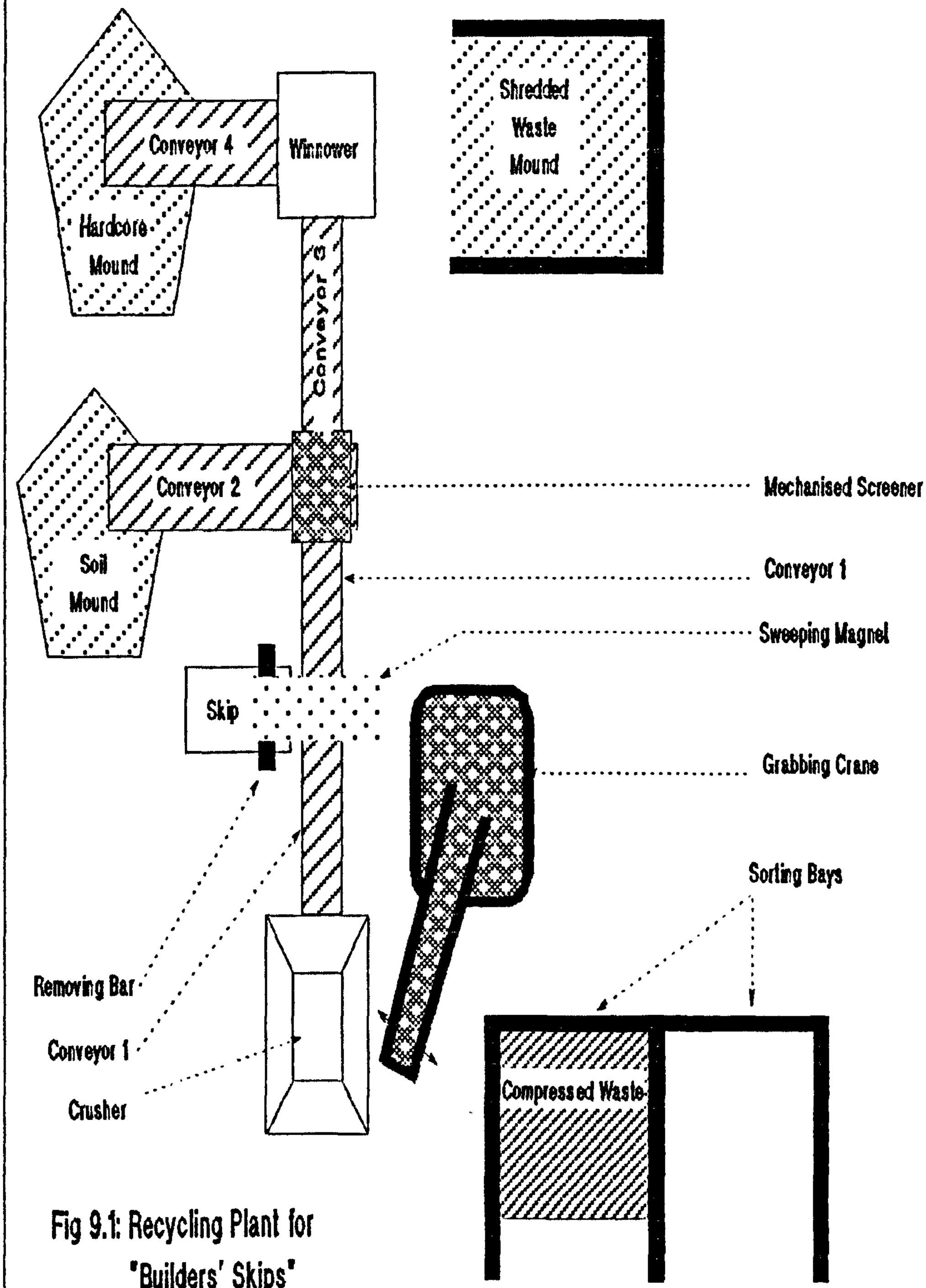


Fig 9.1: Recycling Plant for "Builders' Skips"

"Conveyor 2" deposits fine materials onto the "Soil Mound" which is removed as cover material for landfill sites.

"Conveyor 3" drops the remaining waste into the "Winnower". The "Winnower" is a powerful fan which blows lightweight waste dropped through it off into the "Shredded Waste Mound". Heavier wastes fall onto "Conveyor 4" and are deposited on the "Hardcore Mound".

The "Shredded Waste Mound" consists of lightweight materials which have been considerably shredded by passing through the "Crusher" with denser materials. The shredded waste is sent to landfill where a small discount is offered (negotiated by the transfer station owner) since shredded wastes are easier to landfill (and because the transfer station owner is a valued customer).

The "Hardcore Mound" consists mainly of crushed rubble and wood chips. This material is occasionally exported to forestry sites for use in road building. The majority of this material though is sent to landfill sites where it commands a lower price but where there is enough demand for it.

The site owner said that the operation could be improved by installing a small incinerator to burn the winnowed shredded waste and to generate electricity to power the crusher. He thought that if the incinerator could be rigged to burn this waste as it is blown from the winnower that it would generate a similar amount of energy to that generated by the same weight of oil.

Although this may seem like a "practical" option to the site manager, it may not represent the most "practicable" means from a regulatory point of view. Given the high standards of pollution abatement employed in waste incinerators generally, such an operation would require a considerable amount of investment in pollution containment technology if it is to be licensed. Such costs may not be justifiable for such a small scale incinerator.

The throughput of the operation is limited by the crusher capacity which the owner estimated as 500 tonnes per day. The operation is limited by supply to about half this amount.

The crusher and the crane are purchased plant which cost a total of approximately £1.6 million. Other parts of the operation were built in-house at an unknown cost. The operation also requires the employment of four operatives.

The weighbridge data for the site included descriptions of waste loads delivered. Analysis of loads delivered over two days in February 1993 yielded the results presented in Table 9.1.

Table 9.1: Loads Delivered to the Transfer Station

Container	Waste Type	Average Loads per Day	Average Load Weight (tonnes)
Category B Packer (a small skip)	Builder's	4	1.68
Mini skips	Builder's	4	0.49
Double loaded skips	Builder's	1.5	5.2
Other skips	Builder's	89	3.79
	Cans	0.5	4.76
	Cast Iron	0.5	0.52
	Other Iron	20.5	1.33
	Lead	1.5	0.40
	Short Steel	1	0.96
8 by 4 rear end loader	Commercial	1	17.26

Comparison of these figures with data for other weeks showed a similar breakdown of loads except that deliveries of aluminium are also received about once every two weeks (carrying about 1 tonne each time).

Wastes other than builders waste are not mechanically recycled. The owner said that other materials are simply stored at the station prior to long haulage to recycling facilities in larger vehicles. Further analysis of the station's weighbridge data focussed on the number of loads described as "other skips of builders' waste" which make up the majority of waste mechanically recycled at this facility (95 % by weight from Table 9.1).

Four weeks of data for the facility were analysed. It was noticed that for any week, the numbers of weekday deliveries are consistent over the week whilst there are less deliveries on Saturdays. The facility is closed on Sundays. The data gathered is summarised in Table 9.2.

Table 9.2: Weekly Deliveries to the Transfer Station

	Average Number of Deliveries on - Weekdays		Saturdays	
Seven Working Days Selected	Daily Total	Builder's Waste Total	Daily Total	Builder's Waste Total
20/8/92 to 27/8/92	83	57	34	18
20/11/92 to 27/11/92	101	61	22	7
20/2/93 to 27/2/93	120	83	32	16
15/5/93 to 22/5/93	120	85	35	18

Table 9.2 suggests that the operation experienced a gradual build up of business in skip wastes until February 1993 after which business has levelled off. The weighbridge data for the three months from March to May 1993 was assessed to determine that an average of 82.5 skips of builders waste delivered loads of an average weight of 3.1 tonnes daily. This suggests an average weekday throughput for the recycling operation of 256 tonnes per day.

The owner of the facility said that the recycling operation converts builder's waste into other material in the following proportions by weight;

50% Cover Material
25% Hardcore
25% Shredded Lightweight Waste
Less than 1% metals

He thought that materials manually removed before processing account for less than 1% of throughput.

The transfer station receives considerably more skip loads of builders waste than the nearby landfill site. The owner said that prices are usually negotiated with individual Waste Hauliers. He said that he usually undercuts landfill prices marginally. However he also said that Waste Hauliers use the transfer station for reasons other than price.

One haulier has reported a 30% saving in maintenance costs for vehicles sent to the transfer station compared with the same vehicles previously sent to landfill sites. The owner thought that this is due to the flat concrete surface for vehicles in the transfer station. By contrast vehicles on landfill sites must travel over bumpy temporary roads.

The owner also thought that Waste Hauliers value the relatively quick turn around times at the transfer station of around two minutes. By contrast vehicles visiting a landfill site incur queuing and on site travel times of around ten minutes. If vehicles have to wait for slow emptying domestic waste vehicles this time can be up to fifteen minutes.

These benefits would be worth bearing in mind for landfill operators considering this option. Placing the operation near to a site entrance, and using a permanent road surface would help to attract hauliers to the site (due to reduced vehicle maintanance costs and quick turn around times).

9.3 Method to Assess The Recycling of Builders' Waste At Landfill Sites

The question to be addressed is:

> Under what conditions is it preferable to invest in recycling technology for use at landfill sites rather than continue landfilling wastes without pre-treatment?

The economic effects of recycling in this case, may be stated as:

Change in revenue due to reduced throughput of cover and hardcore materials (relatively low priced wastes).

Replacement of cover and hardcore inputs reduces the net amount of input to a site and extends the site's working life.

Any revenue from sale of reclaimed metals is assumed to be negligible for the small quantities involved.

The costs of recycling may be stated as:

A capital cost required to assess, purchase and install recycling plant at a landfill site.

An operating cost to cover maintenance of plant, fuel and employment of operatives.

For the sake of simplicity, it is assumed the plant depreciates to zero value over the lifetime of the landfill site.

One problem for economic comparison of the alternatives is how to represent costs and benefits which are appreciated at different times. For example, the benefit of extended site lifetime enables revenue to be generated at a future date. This revenue must be compared with other costs and benefits appreciated at different times during the life of the landfill.

In the waste management sector, the discount rate for such investments is commonly considered as 20% or 15%. By comparison the discount rate employed by governmental agencies in the UK is 8%. The rate of 20% is used in Section 9.4 in most cases, although consideration s given to other rates. Comparison of industrial and governmental discount rates reflects the difference between commercial conditions and those which would be expected under investment on behalf of the nation.

The discount rate can be used to determine "Net Present Value" (NPV). NPV represents value in terms of a given year for the value of costs or benefits accrued in a different year. The NPV relative to a given year of a value X, incurred t years after the given year for an agency whose discount rate is d is expressed by the following equation:

$$NPV = X (1 + d)^{-t}$$

Equation 9.1

Calculation of NPV enables costs and revenues to be compared for a landfill site with and without the use of recycling.

The following notation is used below to represent costs and revenues:

K_L Capital cost of the landfill site

K_R Capital cost of the recycling plant

O_L Annual operating cost of the landfill site

O_R Annual operating cost of the recycling plant

C_L NPV of Closure and aftercare costs relative to the year of closure of the landfill site

R_L Annual revenue of the landfill site without recycling

R_R Annual revenue of the landfill site with recycling

V_L Resale value of landfill site

m Operating life of the landfill site without recycling

n Operating life of the landfill site with recycling

d Discount rate

L(x) NPV (relative to year x) of all revenue minus all costs associated with the landfill site without recycling

R(x) NPV (relative to year x) of all revenue minus all costs associated with the landfill site with recycling

Now, consider a landfill site which begins operation in Year 1 (capital costs incurred in Year 0). Assume that recycling begins in Year 1 and that no costs are subject to real increases in value. The total NPV's relative to Year 0 are L(0) and R(0) defined by the following equations (where i represents summation over a number of years).

$$L(0) = -K_L - \sum_{i=1}^{i=m} O_L(1+d)^{-i} + \sum_{i=1}^{i=m} R_L(1+d)^{-i} - C_L(1+d)^{-(m+1)} + V_L(1+d)^{-(m+1)}$$

Equation 9.2

$$R(0) = -K_R - K_L - \sum_{i=1}^{i=n} (O_R + O_L)(1+d)^{-i} + \sum_{i=1}^{i=n} R_R(1+d)^{-i} - C_L(1+d)^{-(n+1)} + V_L(1+d)^{-(n+1)}$$

Equation 9.3

If the recycling option is to be preferred, then according to this analysis R(0) must exceed L(0). From the above equations this condition becomes:

$$K_R \leq -\sum_{i=1}^{i=n} O_R(1+d)^{-i} + \sum_{i=m+1}^{n} (R_R - O_L)(1+d)^{-i} + \sum_{i=1}^{i=m} (R_R - R_L)(1+d)^{-i} + (C_L - V_L)((1+d)^{-(m+1)} - (1+d)^{-(n+1)})$$

Equation 9.4

In other words, viability of the recycling option may be expressed in terms of the capital cost worth paying for proposed recycling plant. This value varies proportionally with the following factors:

inversely with operating cost of recycling plant

with the amount of profit made in additional operating years

with the value of increased revenue in the years up to the lifetime of the landfill without recycling

with the value due to delayed closure costs

inversely with the value of delayed resale

It is interesting to note that according to this analysis the capital cost of the landfill site (excluding the capital cost of recycling plant) becomes irrelevant. This is to be expected as long as the investor does not feel obliged to remain in landfill after the course of one investment in a landfill site. If though, an investor intends to replace a filled site with a new site in order to retain capacity provided by a range of landfill sites then an additional benefit for the recycling option should include the abated need for a new site for the time period by which recycling extends site life.

So far this analysis does not account for real increases in costs. Such increases reflect changes in landfill practice induced by environmental concern amongst the general public, legislators and responsive businesses. BCWM consider landfill costs to be rising due to;

public pressure opposing new sites,

legislation demanding tougher engineering standards to prevent leaching and methane leakage

quarrying businesses locating sites (which may become viable for landfill) further from populated areas.

BCWM provided data which showed cost increases observed from 1990 to 1992. These increases may be approximated to fixed rate annual increases. These increases are used in Section 9.4, in conjunction with the above NPV calculating process in a spreadsheet model.

9.4 A Calculating Model

The analysis tools presented in Section 9.3 are applied here, using a spreadsheet model. The spreadsheet model enables R(0) and L(0) to be calculated and compared for many different values of other variables.

The model presented here relies on four assumptions.

Assumption 1: Capital costs occur over the same year for landfill and recycling costs. This year is set as Year 0 (the first day of the first year of the calculation) for landfill costs and in most cases for recycling costs.

In reality capital costs of landfill occur over more than one year. Preparation work for landfill sites includes;

Site assessment
Planning applications
Site engineering

All these activities cost money and may be conducted years in advance of a site opening. However, it is demonstrated in Section 9.3 that landfill site capital costs do not feature in the comparison of options according to the model presented. The model presented here could be adapted to include costs for Year -1 and so on if the objective were to improve the

description of landfill capital costs and if appropriate data for landfill capital costs could be gathered.

Assumption 2: All costs are subject to real annual increases above the rate of inflation. These cost increases are represented as an annual rate derived from data on costs for the years 1980 and 1992 supplied by BCWM.

Although the data supplied by BCWM does show such cost increases, some increases are associated with one off changes in landfill construction and operating costs. For example between 1980 and 1992, landfill sites incorporated leachate and methane extraction facilities. These facilities considerably increased capital costs and also required a small increase in operating costs. There is no reason to expect that cost increases from 1992 to 2004 will be at a similar rate.

On the other hand, it is thought by BCWM that costs will continue to rise in real terms in the landfill sector due to ever increasing standards and the possibility of a government imposed landfill tax.

The effect of reduced cost increases is considered in Section 9.5.

Assumption 3: Operating costs occur from the first year after capital costs are accrued for a number of years equal to site lifetime. Site lifetime is considered as site volume divided by volume of annual throughput to the nearest whole number.

This assumption inherently presumes a constant site throughput. Landfill operators may seek to have higher throughput during the earlier years of a site's life in order to recover capital costs as quickly as possible. The data used for the model was based on one year's throughput for one of BCWM's landfills. Further research would be required to gather data on the profile of waste throughput over time.

The calculation of site lifetime involving volume of throughput relies on Assumption 4.

Assumption 4: The density of waste in the filled site is 1 tonne per cubic metre.

Different wastes have different densities. However this variability is partly compensated for by the fact that wastes in landfill sites become compressed to a more homogeneous density. The figure used was supplied by BCWM based on their experience of known site volumes and total throughputs.

The figure simplifies the modelling task since throughput measured in tonnes can be equated with throughput measured in cubic metres. If an improved estimate were provided the model presented could be easily corrected by adjusting site size or throughputs by an appropriate factor.

The method described in Section 9.4 requires values to be known for the variables used in Equation 9.4. Data available from BCWM was manipulated to find values for these variables. The following sources of data were available;

Estimates of capital and running costs for a landfill site of a total volume around 5 million cubic metres were provided by BCWM. Annual rates of

increase for these values were also provided based on BCWM's experience from 1980 to 1992.

An annual summary of weighbridge data for the site to be modelled in 1992 was available. However, the site is an unlikely choice of site for recycling due to the nearby transfer station which recycles builders waste (described in Section 9.3). 95 % of the builders waste processed at this facility accounts for 256 tonnes per day of throughput of which 50 % is converted to cover material, 25 % to hardcore and 25 % to lightweight waste. If this site were not present, then the Landfill would receive more waste in skips and less cover material, hardcore and other waste. The weighbridge data for the Landfill was modified to model a landfill without a nearby recycling facility. One run of the model does however use the original data to account for the presence of a nearby recycling facility as a "condition" upon which viability of recycling depends. Total annual throughput for the site and percentage of annual throughputs were determined for;

Cover material
Hardcore
Skip waste
Other waste

The published price list for the Landfill for April 1992 was used to determine the prices charged for wastes for which throughputs were determined. For "other wastes" this involved the following calculation.

For waste categories of a given price calculate annual revenue by multiplying the price by the sum of all throughputs (identified in the summary of weighbridge data) charged at that price. Repeat this calculation for all waste categories differing by price. Sum the annual revenues calculated. Divide this figure by the total throughput of "other wastes".

A similar calculation was performed for "skip wastes" (those suitable for recycling) for each category of skip size.

Resale value of recycling plant was considered to be negligible.

The percentage of cover and hardcore materials recyclable from skips (the recycling ratio) was given by the transfer station operator (see Section 9.2).

Recycling capital costs and running costs were taken as output for the model. These costs were assumed to increase at similar rates to those given by BCWM for heavy plant used on landfill sites.

The data gathered were used as initial input values for the model. Table 9.3 lists the variable names used and the values for the variables gathered from the data sources given above and which are used as default values for the model.

Table 9.3: Variables and Their Default Values
(determined from data sources)

Name	Variable	Default Value	Notes
S	Landfill Pit Size	5,000,000 m^3	S/T = Pit Lifetime
T	Annual Throughput	308669 tonnes pa.	
D	Discount Rate	20%	15% and 8% are also used
KL	Capital Cost of Site	£4,000,000	KL does not influence recycling viability as modelled
OL	Operating Cost of Site	£750,000 pa.	OL is varied in Scenarios 1 and 2
CL	Restoration Cost of	£250,000 pa.	
A1L	Cost During Period 1 of Site Aftercare	£25,000 pa.	
A2L	Cost During Period 2 of Site Aftercare	£10,000 pa.	
AY1	Duration of Period 1 of Site Aftercare	5 Years	
AY2	Duration of Period 1 of Site Aftercare	25 Years	
VL	Resale Value of Site	£1,000,000	Occurs in the year after AY2 is complete
PC	Price Charged for Cover Material	£1/tonne	
PH	Price Charged for Hardcore Material	-£1.50/tonne	Negative value represents price paid rather than charged
PS	Price Charged for Skip Waste	£8.00/tonne	PS is varied in Scenario 5
PO	Average Price Charged for Other Wastes	£11.00/tonne	

Table 9.3 Continued: Variables and Their Default Values (determined from data sources)

Name	Variable	Default Value	Notes
TC	Throughput of Cover Material	13%	Percentage of T (above)
TH	Throughput of Hardcore Material	3%	Percentage of T (above)
TS	Throughput of Skip Waste	20%	Percentage of T (above)
TO	Throughput of Other Waste	64%	Percentage of T (above)
RC	Recycling Ratio Cover : Skip Waste	50%	Percentage of cover material recycled from skip waste
RH	Recycling Ratio Hardcore : Skip Waste	25%	Percentage of hardcore recycled from skip waste
KR	Capital Cost of Recycling Plant	£0 to £2,000,000	Varied in £1 Million increments
OR	Operating Cost of Recycling Plant	£X	X is the output value for "indifference" (see below)
VR	Resale Value of Recycling Plant	£0	
RY	Year to Invest in Recycling	0	RY is relative to Year 0

A spreadsheet model was developed to compare NPV's of the costs of running a landfill with and without recycling builders' skips for cover and hardcore materials. Fig 9.2 shows a block diagram of this spreadsheet. A copy of the spreadsheet with sample values is presented in Appendix 3.

Block 1 contains input data from Table 9.3 and calculated annual revenues.

Block 1a includes global variables (Start Year, Pit Capacity (S), Annual Throughput (T), Discount Rate (D) and Inflation.

Block 1b contains values for Annual Capital, Operating, Restoration and Aftercare Costs as well as Resale Value for the Modelled Landfill Site (KL, OL, CL, A1L, A2L and VL).

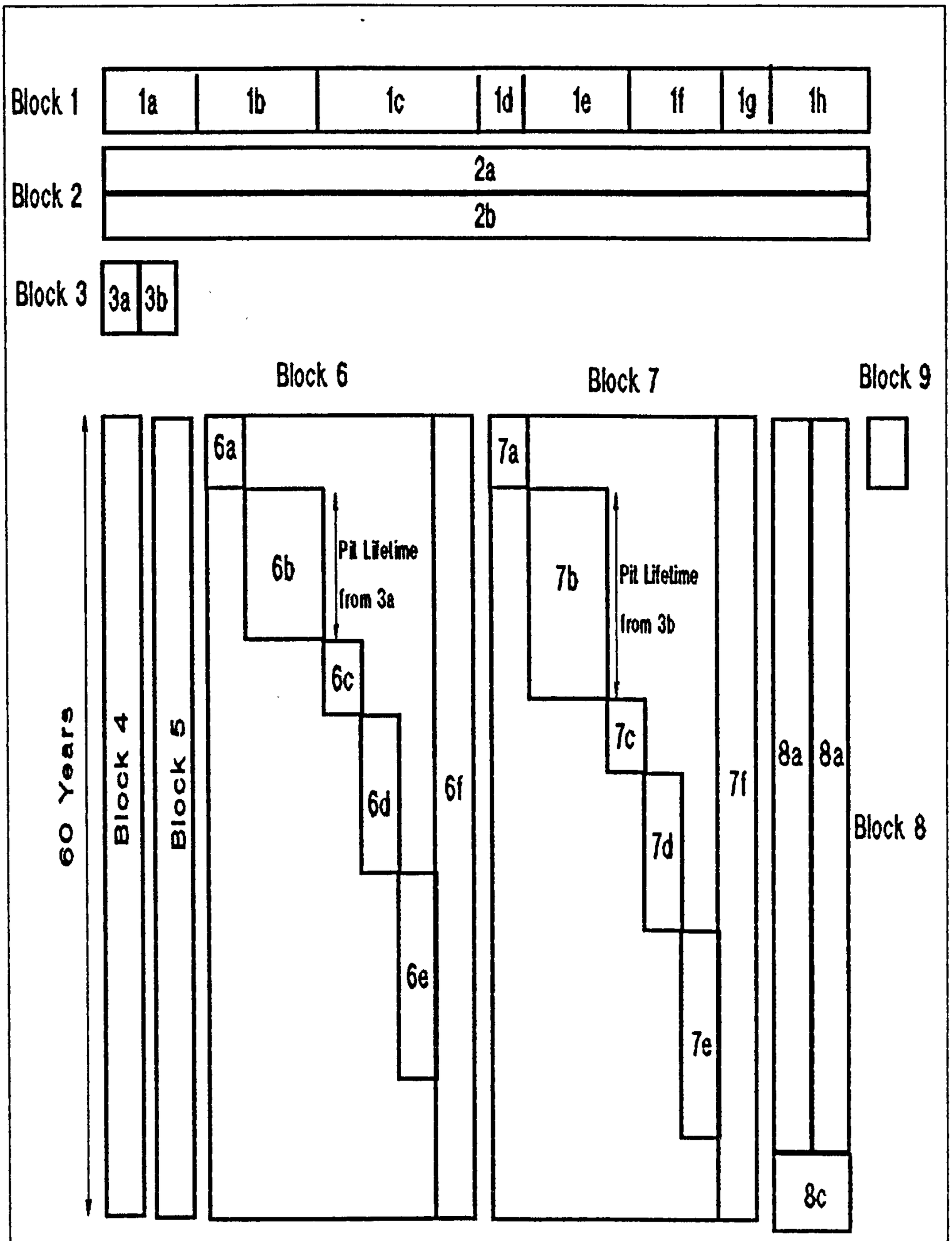


Fig 9.2: Block Diagram of the Spreadsheet used to Compare Costs of Landfill With and Without the Recycling Option

Block 1c contains average prices charged per tonne and throughput percentages for Cover, Hardcore, Skips and Other Wastes (PC, PH, PS, PO, TC, TH, TS, TO).

Block 1d calculates annual revenue for the modelled site (RL) calculated as:

$$(PC \times TC \times T) + (PH \times TH \times T) + (PS \times TH \times T) + (PO \times TO \times T)$$

Block 1e contains values for capital and operating costs for recycling plant (KR and OR) which are model inputs and outputs. For different values of KR, the spreadsheet is used to calculate values of OR for which recycling is equally preferable to landfill alone. This process is described below in more detail.

Block 1f contains values for recycling fractions (the ratio of useful material produced to skip waste brought for recycling) of Cover and Hardcore (RC and RH) which are 50% and 25% respectively.

Block 1g calculates the contribution to revenue of the recycling operation (RR) due to the value of cover and hardcore waste replaced by the recycled material on the Landfill as:

$$-T \times (TS \times RC \times PC + TS \times RH \times PH)$$

Block 1h contains values for the time periods of aftercare (A1Y and A2Y) and the year in the landfill's life in which investment is to be made in recycling plant (RY) which is usually set as zero.

Block 2 contains values for annual rates of increase for all input values (call this rate "a"). The values given by BCWM are placed directly below the appropriate input values in Block 2a. Block 2b calculates real rates of increase (for which increases due to inflation, "i," have been removed) as

$$((1 + a)/(1 + i)) - 1$$

Block 3 calculates site lifetimes for the modelled landfill site with and without recycling. In the latter case, site lifetime is increased due to reduced throughput of hardcore and cover material which is replaced by recycled materials.

Block 3a - For landfill only, site lifetime is

$$S / T$$

Block 3b - For landfill with recycling, site lifetime is;

$$RY + ((S - (T \times RY)) / (T \times (1 - RC \times TS - RH \times TS)))$$

Block 4 is one column giving the year (Y) of the Model Site's lifetime, beginning at 0 and continuing to 60 (more than any site is likely to require, even accounting for aftercare). Each consecutive row of the model represents a consecutive year of the model site's lifetime.

Block 5 is one column which calculates a "discount factor" (call this factor "F") based on the discount rate (D) and the year (Y) for each year as;

$$1 / (1 + D)^{Y}$$

Block 6 calculates NPV's for values given in Block 1b for each year of the site lifetime (without recycling). For each year (Y) the discount factor (F) from Block 5 is used with appropriate variables from Block 1b (call these "G") and the real annual rates of increase in Block 3 (call this rate "b") to calculate the annual NPV for each cell as

$$F \times G \times (1 + b)^{Y}$$

Block 6a is a single cell which calculates the NPV of KL (capital cost) always modelled as occurring in Year 0.

Block 6b consists of two columns which calculate NPV's of OL and RL (operating costs and revenue) for each year of the modelled Site's lifetime (from Block 3a).

Block 6c is a single cell which calculates NPV of CL (closure cost) for the year after the last year of the modelled Site's lifetime.

Block 6d calculates NPV's of A1L (aftercare cost of checking that escape emissions are safe) for each year of the first period of aftercare (A1Y).

Block 6e calculates NPV's of A2L (in the second period of aftercare, costs are lower since emissions need to be checked less frequently) for each year of the second period of aftercare (A2Y).

Block 6f calculates NPV for VL (resale value of site) for the year after the second period of aftercare is complete.

Block 6g calculates annual totals of all costs and revenues calculated in Blocks 6a to 6e.

Block 7 is similar to Block 6 except for two differences:

Site lifetime is modelled as extended due to recycling (from Block 3b). Hence Block 7b calculates OL and RL for more years than Block 6b does. Costs incurred after the end of site lifetime are modelled as delayed by being located further down the spreadsheet (hence they are subject to real increases over more years and subject to more discounting).

The landfill revenue (RL) is modified by addition of the contribution to revenue (RR) calculated in Block 1g (which is negative in this case).

Block 8 consists of two columns which calculate Cumulative NPV (CNPV) for each year for the modelled landfill without recycling (Block 8a) and with recycling (Block 8b). The value for each year is calculated as the sum of values for that year and each preceding year from the total values calculated in Blocks 6g and 7g. Block 8 extends to cover sixty years regardless of lifetime since this period of time is sufficient to

cover all cases considered in the analysis below. Cells representing years after which costs and benefits are accrued, simply repeat the CNPV for the year in which resale value (RL) for the site is appreciated. Block 8c consists of the two cells which show CNPV's in the sixtieth year for the modelled Site with and without recycling.

Block 9 consists of one cell showing the difference between CNPV's for the modelled site with and without recycling. When the value shown in this cell is zero, then the model represents a case for which recycling is equally preferable to continuing to landfill waste without recycling.

The calculating model represents the difference in worth between a landfill site with and without the recycling option. The difference modelled is due to reductions in throughput of hardcore and cover materials imported, achievable by recycling these materials from waste brought to the site in "builders' skips". This change in throughput reduces revenue and extends the working life of the site. Fig 9.3 shows that this difference develops over time. The lines plotted in Fig 9.3 are the values from Block 8 (CNPV). In this case, the capital cost of the recycling operation (KR) is zero.

From Fig 9.3 it is apparent that closure and aftercare costs are negligible, since the costs curves level out without a significant drop after revenue is no longer accrued. In the case represented, landfill without recycling is the preferable option.

One benefit of using a spreadsheet is that single input variables can be changed and any cells with values that depend on the variable change automatically. However, one variable in the model does not behave in this way. If the site lifetime is changed, empty cells in the model do not know that they should change also. Site lifetime changes if any of the following input variables change;

pit capacity (S)
annual throughput (T)
skip throughput percentage (TS)
the recycling fractions (RC or RH)
the year to invest in recycling (RY)

In the last three cases site lifetime only changes for the landfill with recycling option.

In order to save time adjusting the spreadsheet a "macro function" was written which automatically fills Blocks 6 and 7 with appropriate functions and according to site lifetimes calculated in Block 3 for given inputs. This function is called **"Macro 1"** below.

The model was designed to determine conditions under which the recycling option is preferable to not recycling. Two key conditions for this analysis are the capital and running costs for recycling plant. The relationship between these variables was modelled using the following method.

Step 1 - Use Macro 1 to fill the calculating cells and set recycling capital cost (KR) to zero.

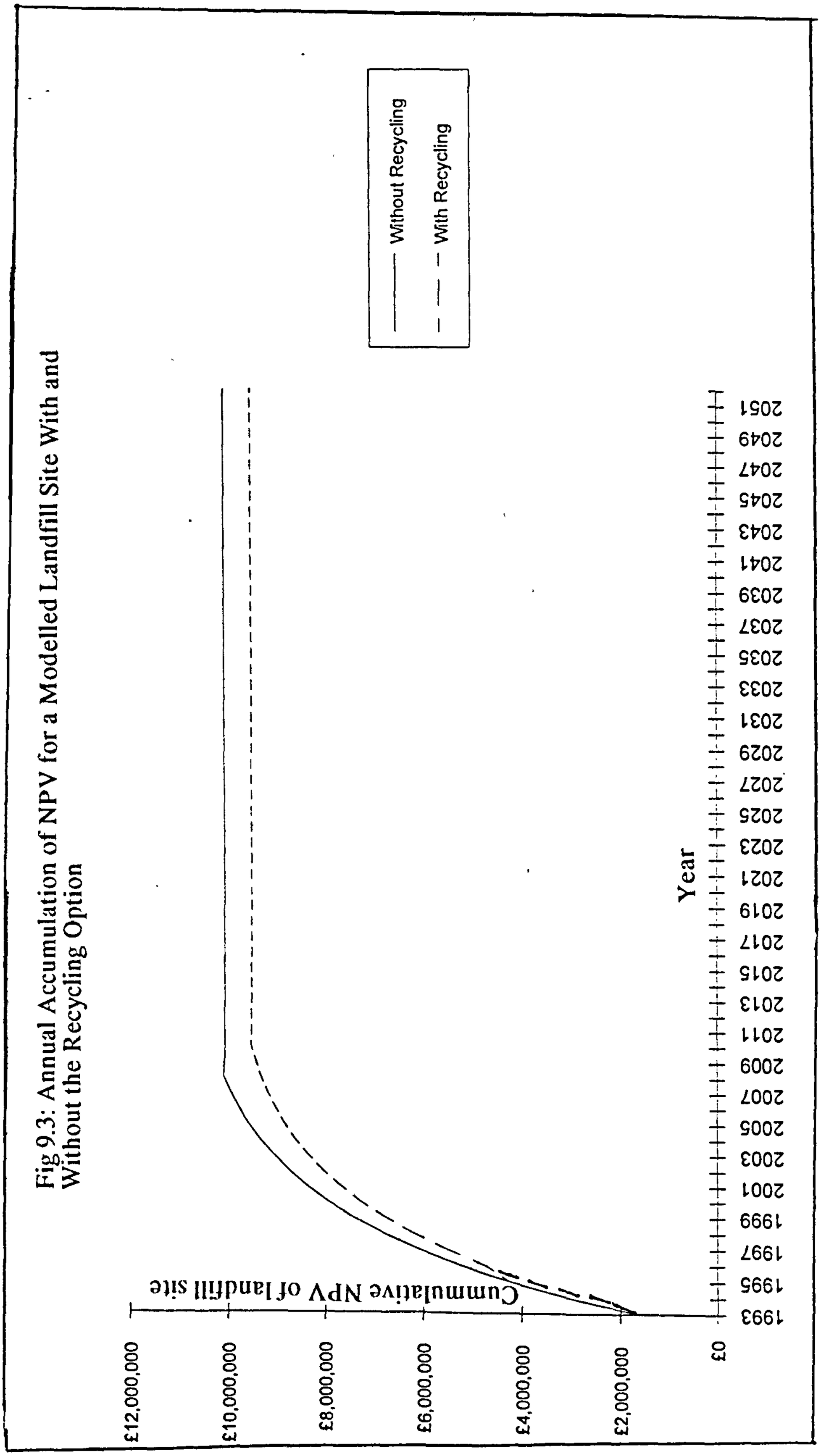


Fig 9.3: Annual Accumulation of NPV for a Modelled Landfill Site With and Without the Recycling Option

Step 2 - Use the model to find the value for recycling operating cost (OR) which returns a value for CNPV difference of zero. Record the values of KR, OR and all input values for each value of KR.

Step 3 - Set KR to £1,000,000.

Step 4 - Repeat step 2.

Step 5 - Set KR to £2,000,000.

Step 6 - Repeat step 2.

Changing values for KR in Steps 1, 3 and 5 is achieved using Excel's "What If" function. This function allows a set of input values to be assigned to a variable which are inputted consecutively using a keystroke. This speeds up the task of inputting values for KR.

Step 2 is achieved using Excel's "Goal Seek" function. This function allows a value sought and the cell reference of a variable on a spreadsheet to be inputted as a "goal" to be achieved. In this case, the value zero is sought for the cell showing the value for CNPV difference (Block 9). A second cell reference is then inputted to identify a cell the numeric content of which is to be changed in order to achieve the goal. In this case, the cell showing the value of OR is selected (in Block 1e). Excel then systematically alters the value in the OR cell until a zero value is achieved for the CNPV difference.

Step 2 is completed by copying the input values (Block 1) and the CNPV modelled for the site (Block 8c) to a convenient location elsewhere on the spreadsheet.

The process of performing steps 1 to 5 was recorded as a macro function called **"Macro 2."** Note that Macro 2 uses Macro 1. Macro 2 was run for different values assigned to model inputs which are called **"Scenarios"** below.

The data recorded for values of KR and OR for given values of other inputs were represented on graphs. The data define three points which always occur on a straight line as in Figs 9.4 to 9.11. This linear relationship is unsurprising (see Section 9.3). Any points below the line represent values of KR and OR for which CNPV difference is negative in which case landfill with recycling is preferable to landfill only. Conversely points above the line represent values of KR and KO for which landfill only is preferable.

These lines are called **"indifference lines"** below.

Indifference lines were drawn for different scenarios. In this way conditions other than capital and operating costs for recycling plant are considered. In most cases, scenarios take one input variable and consider two alternative values other than the default setting for the variable.

Sets of indifference lines were generated for the following scenarios.

Scenario 1: Different Operating Costs for the landfill site

The value for operating cost used for the default setting (£750,000) was thought to be accurate to within +/- £250,000. The spreadsheet model was used to generate indifference lines for three values of operating cost;

£500,000
£750,000
£1,000,000

By varying operating cost without varying revenue, the viability of the recycling option is explored under different conditions of profitability for the landfill site. The indifference lines generated are shown in Fig 9.4.

Scenario 2: Different Operating Costs for the landfill site, with a competing recycling facility nearby

The default values used for throughput percentages are based on combined totals of throughput for a landfill and the nearby recycling facility described in Section 9.3. It was assumed that implementation of the recycling option was to be considered for sites without such competition nearby. The catchment model presented in Chapter Eight could be used to consider cases where recycling facilities compete with landfill sites and other recycling facilities. In this case though, the weighbridge data can be used without the modifications that represent removal of the nearby recycling facility.

This scenario changes the default values to represent the input aggregation for materials at the landfill site only. This is referred to as **"Input Aggregation 1"** below. These changes are summarised in Table 9.4

Table 9.4: Input Aggregation 1

Waste type	Default Value	Input Aggregation 1 Value
Skips (TS)	20%	4%
Cover (TC)	21%	13%
Hardcore (TH)	7%	3%
Other (TO)	68%	64%

Indifference lines for the three values of operating cost given in Scenario 1 (each using Input Aggregation 1) are shown in Fig 9.5. Comparison of the output of this scenario with the output of Scenario 1 illustrates differences in the viability of the recycling option due to the presence of a nearby competing facility for various conditions of operating cost.

Scenario 3: Different Discount Rates

In Section 9.3, three discount rates are mentioned. The default value used for most scenarios is 20% which is a rate commonly used in the waste management industry for investments in new technology which may involve appreciable risk. A discount rate of 15% is used in the landfill industry for lower risk investments. 8% is the figure used by governmental agencies assessing investments.

Fig 9.4: Indifference Lines for Scenario 1 - various operating costs

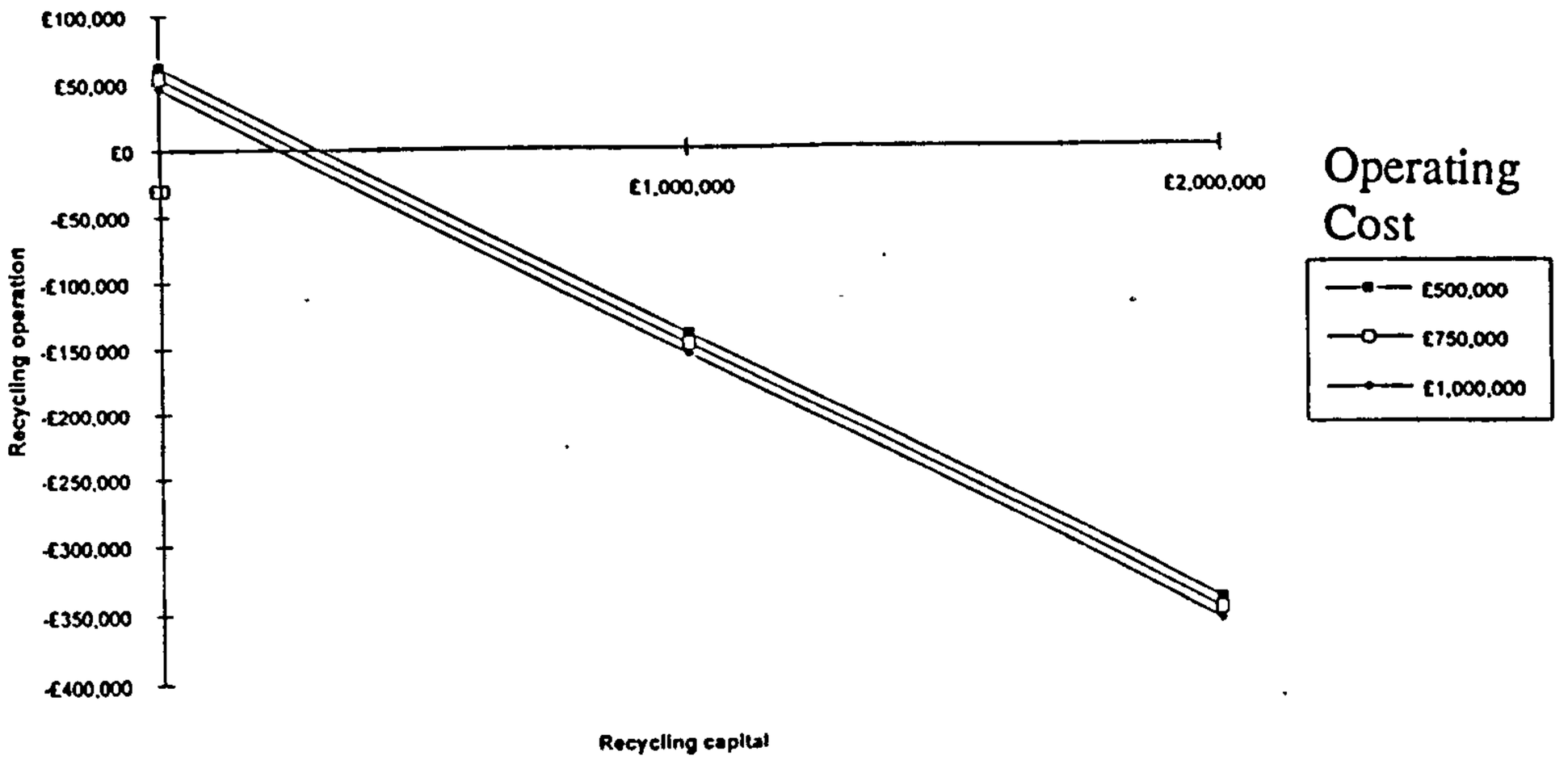
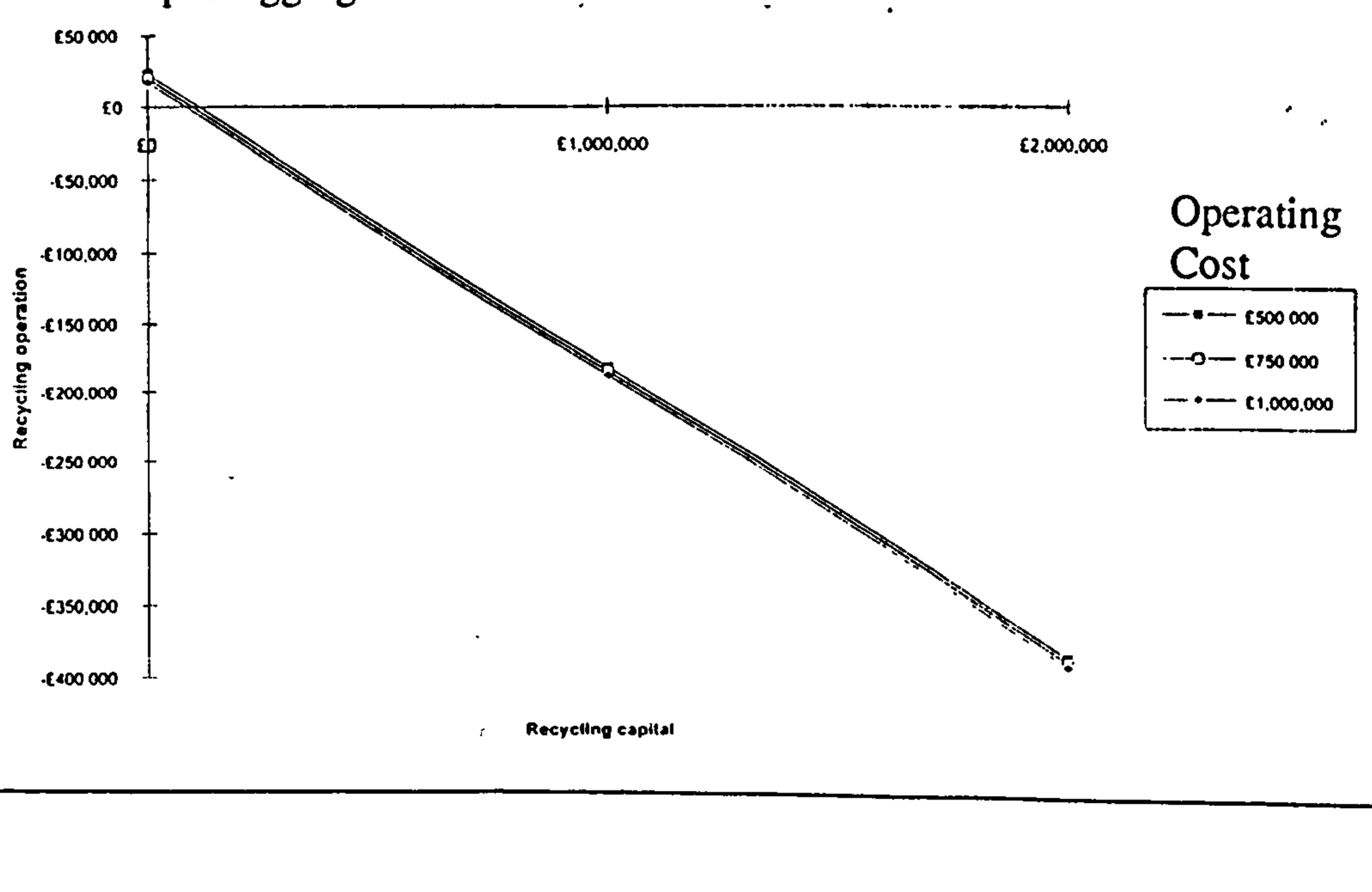


Fig 9.5: Indifference Lines for Scenario 2 - various landfill operating costs for Input Aggregation 1



The model was used to generate indifference lines for these discount rate values which are shown in Fig 9.6. These lines represent conditions associated with the investment requirement of different agencies and how they influence the perceived viability of the recycling option.

Scenario 4: Different Discount Rates for Input Aggregation 1

This scenario is similar to Scenario 2 except that instead of vary operating cost, discount rate is varied as in Scenario 3 with Input Aggregation 1 (shown in Table 9.4). The lines of indifference generated for this scenario are shown in Fig 9.7.

Scenario 5: Input Aggregation 2 and Input Aggregation 3

The catchment model presented in Chapter Eight showed that reducing the price charged for skip waste could increase catchment area. Considering that builders skips carry about 3 tonnes of waste and the transport cost per mile for a skip loader is about £1.50 per mile, then it follows that the cost of transporting builder's waste is about £0.50 per tonne per mile. In Fig 8.7 (reprinted here for easy reference) this transport cost can be considered as defining a line approximately halfway between the lines shown for transport costs of £0.40 and £0.60 per tonne per mile. Estimates may be made that reducing the price charged per tonne of builders' rubble from £8.00 to £4.00 increases catchment (and therefore throughput) by half whereas a reduction to £2.00 doubles the catchment (and therefore throughput).

"Input Aggregations 2 and 3" shown in Table 9.5 are based on these estimates.

Table 9.5: Input Aggregations 2 and 3

Variable	Default Value	Input Aggregation 2 Value	Input Aggregation 3 Value
Skip Price	£8.00	£4.00	£2.00
Throughputs:			
Cover	13%	12%	11%
Hardcore	3%	3%	3%
Skips	20%	27%	33%
Other	64%	58%	53%

Indifference lines for the input aggregations shown in Table 9.5 are shown in Fig 9.8.

Scenario 6: Different Times to Start Recycling

Implementation of the recycling option may not be feasible as early as Year 0. The consequence of starting to recycle builders' waste at a later date than Year 1 (recycling starts the year after investment costs occur) for the viability of the operation is considered by generating indifference lines for the Recycling Investment Year (RY) in Years 0, 5 and 10. These lines are shown in Fig 9.9.

Fig 9.6: Indifference Lines for Scenario 3 - various discount rates

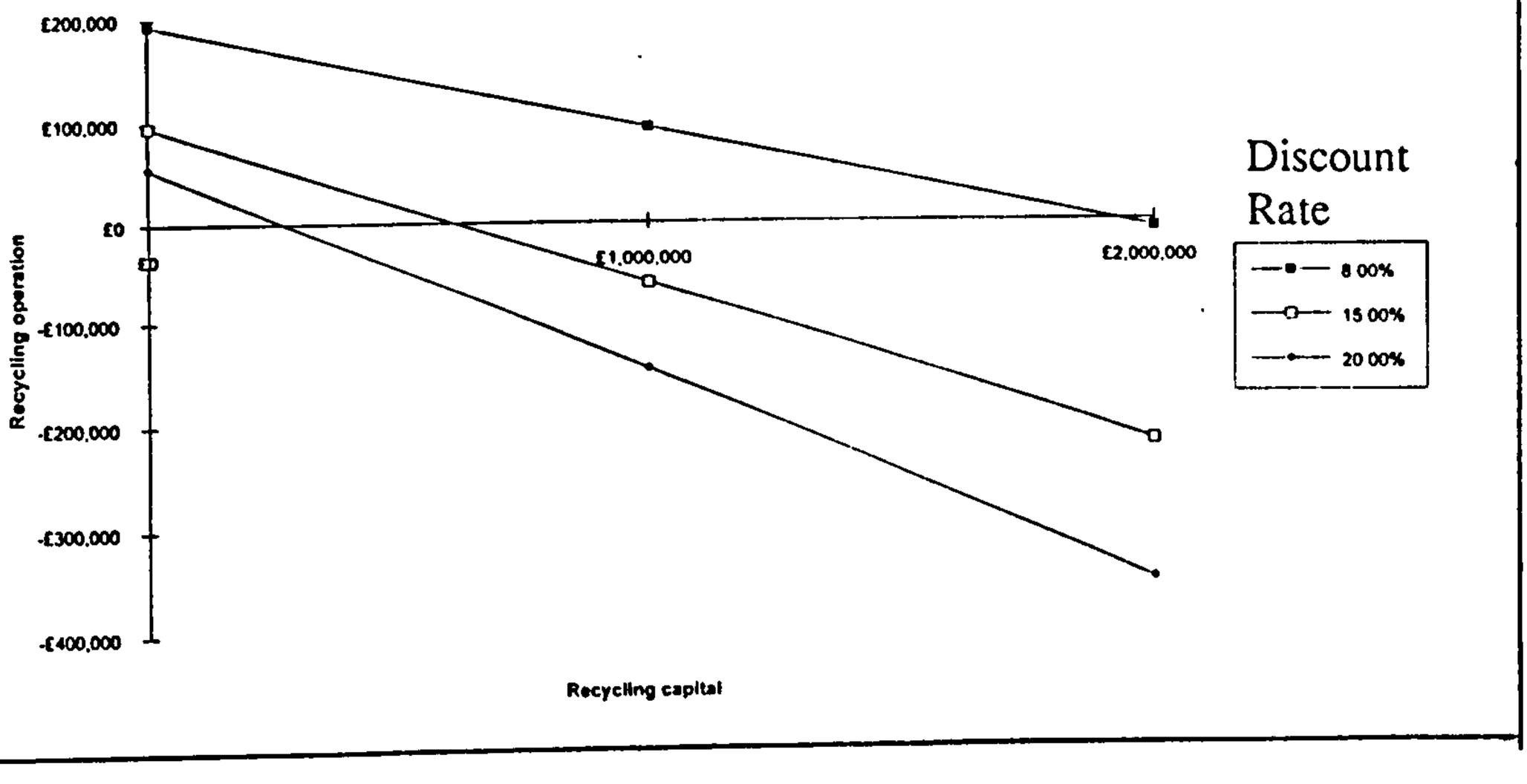


Fig 9.7 Indifference Lines for Scenario 4- various discount rates for Input Aggregation 1

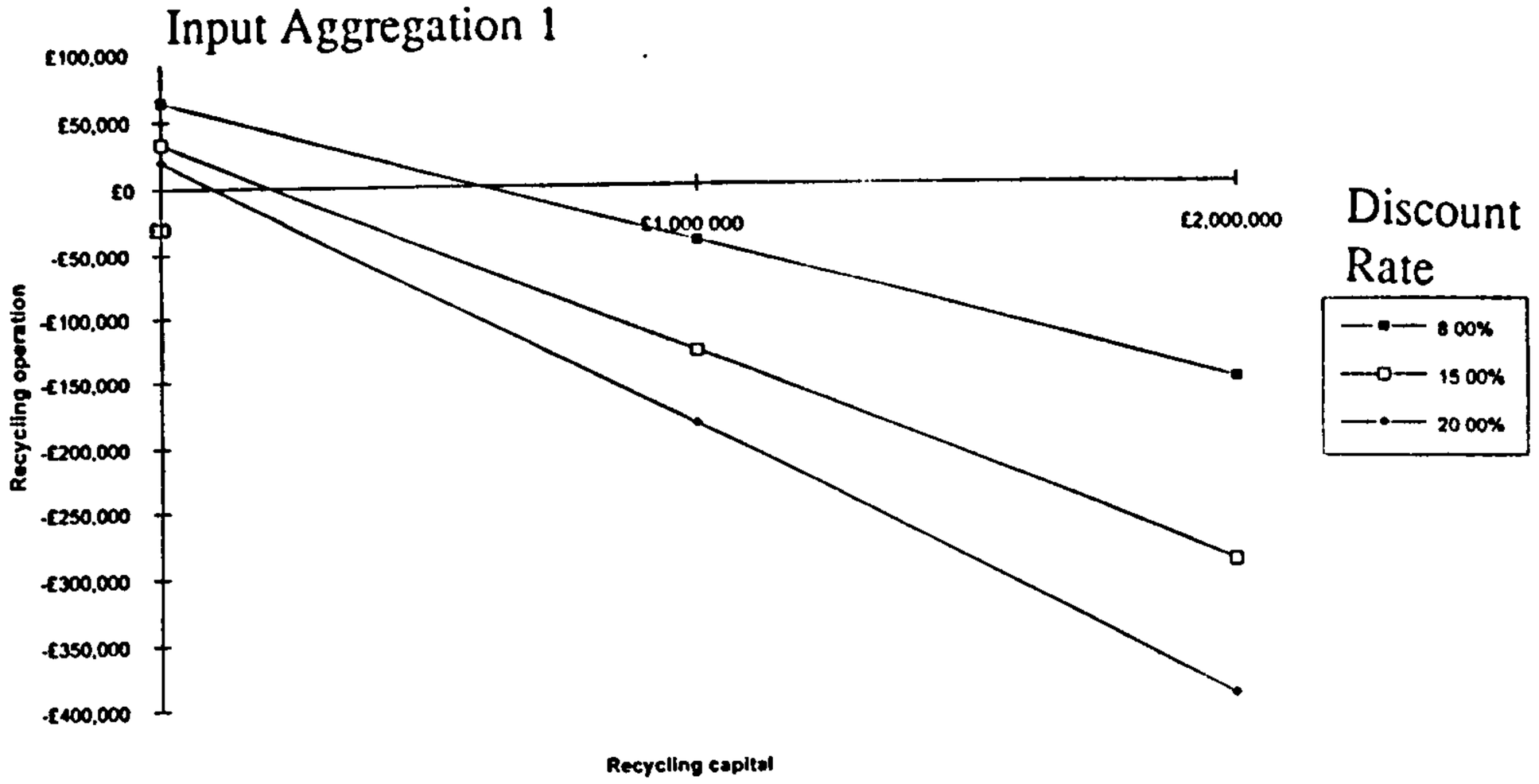


Fig 8.7: Catchment of Site 0 as Modelled for "Builders' Rubble" for various Gate Prices and Transport Costs

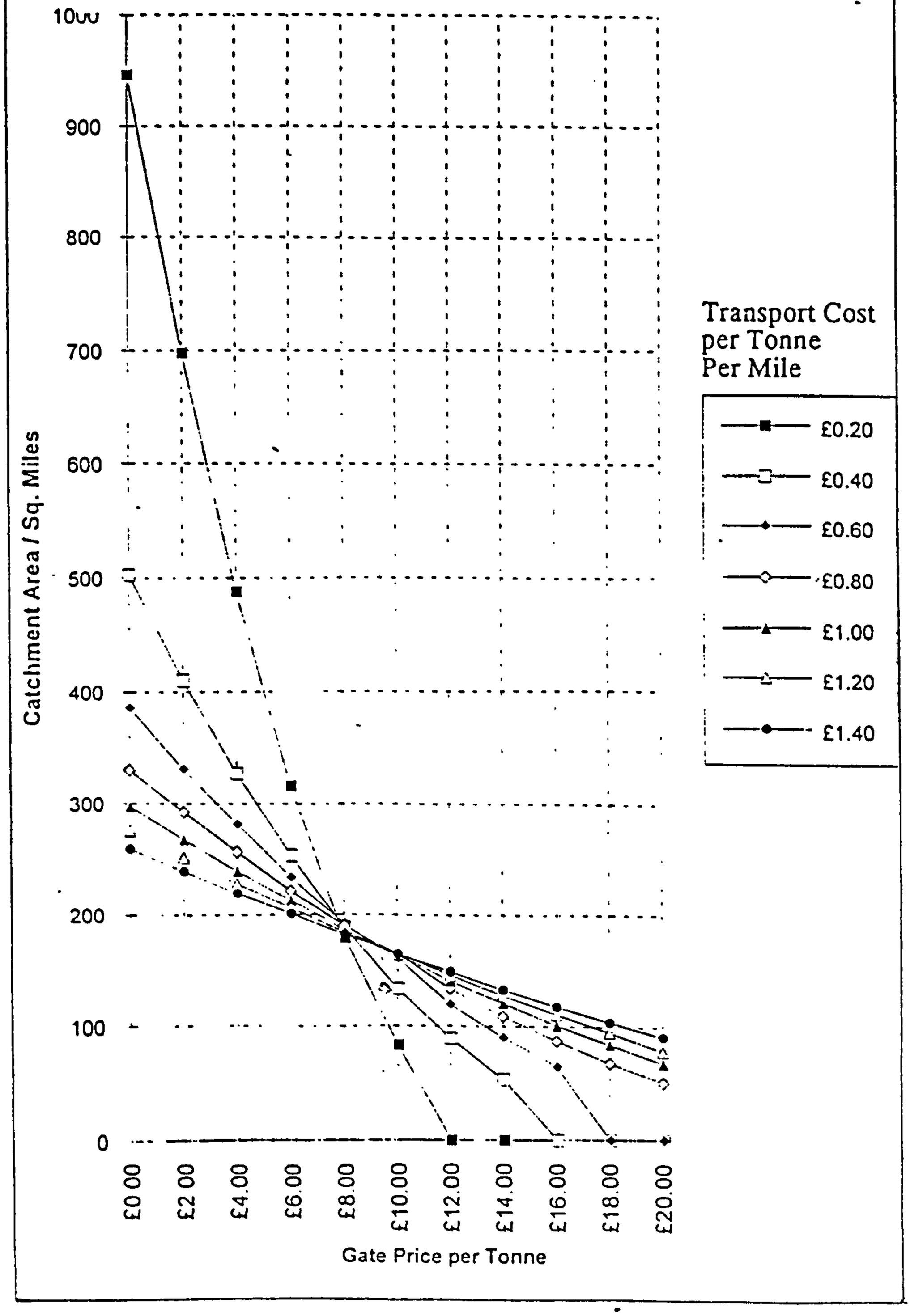


Fig 9.8: Indifference lines for Scenario 5 - Input Aggregations 2 and 3 determined for various prices charged for "builders` skips"

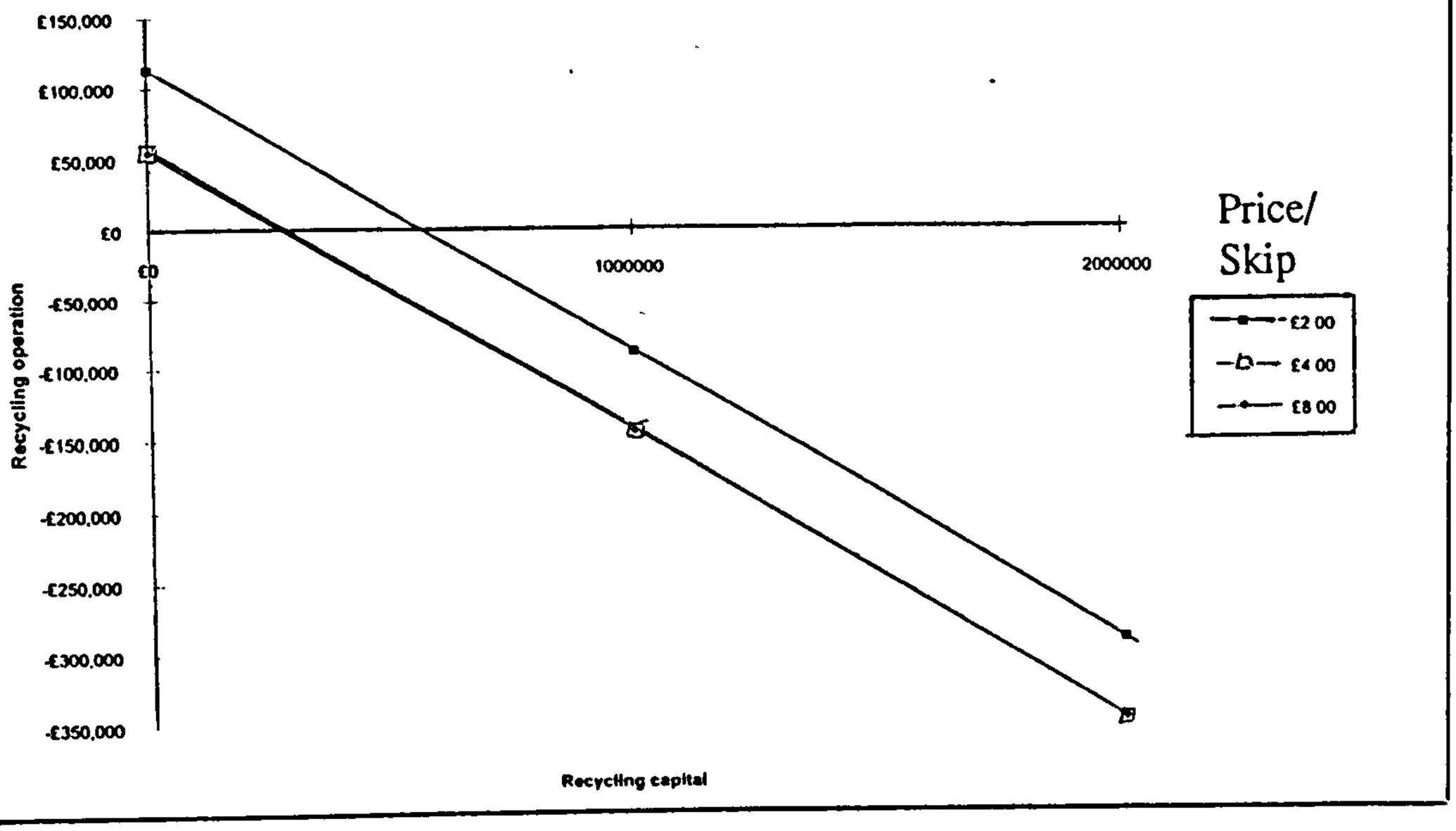
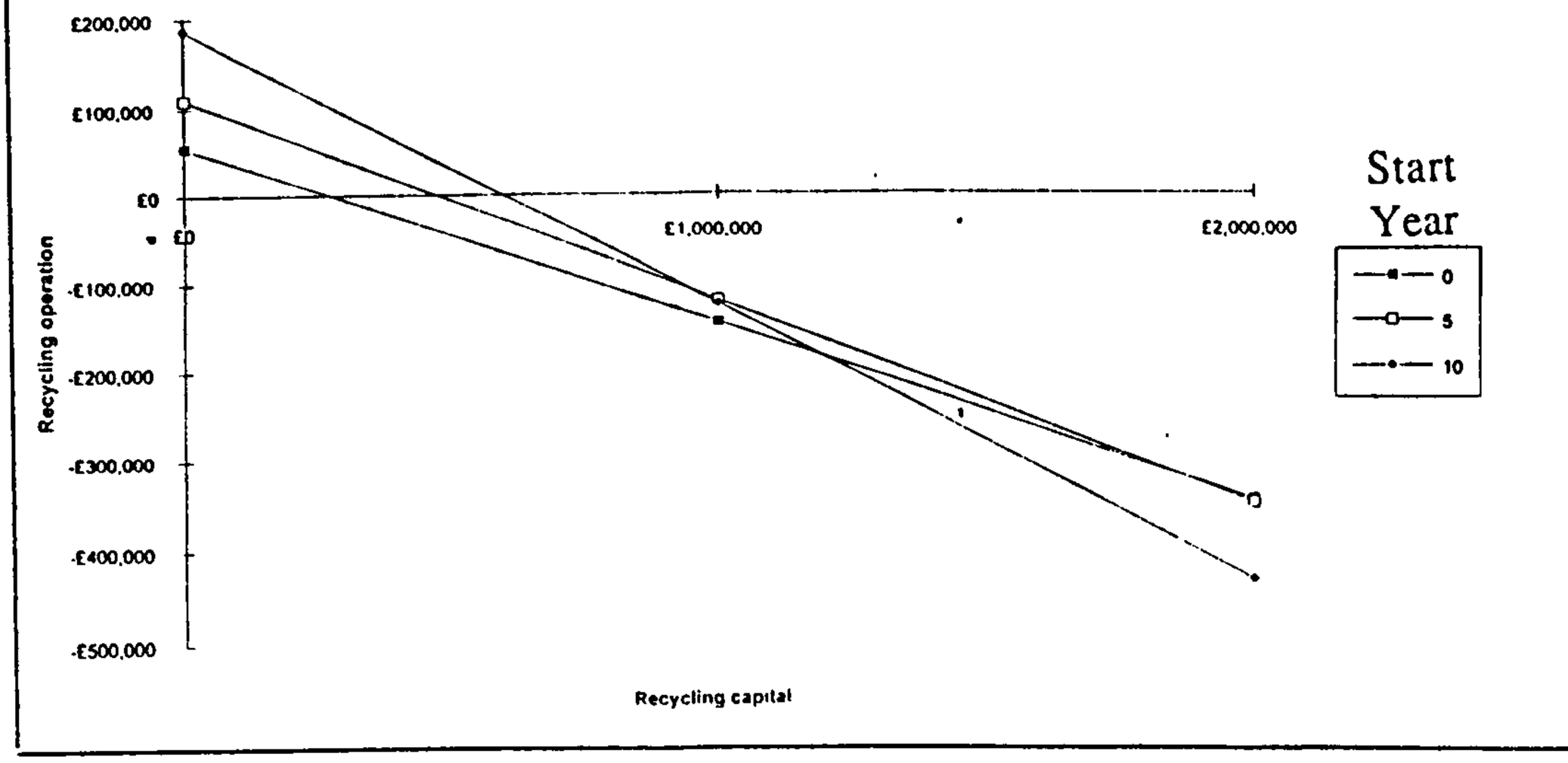


Fig 9.9 Indifference Lines for Scenario 6 - different times to start recycling according to investments made in different years of landfill site lifetime



Scenario 7: Different Sizes of Landfill Site

Different sizes of landfill (with the same throughput) have different lifetimes. Using the values 2 million, 5 million and 8 million cubic metres for landfill size, the lines of indifference shown in Fig 9.10 were generated.

Scenario 8: Reducing Real Cost Increases to Zero

The data for annual rates of cost increase are based on cost increases experienced by BCWM from 1980 to 1992. If these cost increases represent one-off changes that are unlikely to require further additional change in the future, then there is no reason to expect that landfill costs will continue to rise at a faster rate than inflation.

The model was run with annual rates of increase and again with these rates set to zero. The indifference lines generated are shown in Fig 9.11.

NB. the model was also run with variations in landfill capital cost (KL) with the result that no change to the line of indifference occurred regardless of the amount of increase or decrease used.

Other scenarios could have been used such as;

> Changing restoration costs, aftercare costs, duration of aftercare or resale values (CL, A1L, A2L, AY1, AY2, VL VR). Fig 9.3 indicates that realistic values of these variables have a negligible effect on CNPV for a landfill site. Although resale value of recycling plant (VR) is not represented (since its default value is zero) it is unlikely to exceed a few hundred thousand pounds. This is of the same order of value as the site restoration cost (CL) which is hardly noticeable in Fig 9.3. These variables were not analysed as scenarios since their effect on viability of recycling is very small.
>
> Other input aggregations could be generated, with or without associated price changes. Scenarios 2 and 8 involve changes to input aggregation which model specific conditions which may occur due to identifiable reasons (a competing recycling operation nearby or reduced prices to attract more skips). It would be possible to generate families of indifference lines to model a whole range of conditions (eg skip prices modelled at 50p increments and skip throughput at 5 % increments). Such an exercise would be time consuming and difficult to understand if the particular cases modelled are not associated with real situations.
>
> Combinations of Scenarios can be modelled. Scenarios 2 and 4 involve consideration of two kinds of condition. In these cases, the change to input aggregation would have only generated one indifference line if considered in isolation. Combining two scenarios each of which involve three values for a variable would generate nine indifference lines. This would be worthwhile if some necessary relationship between variables were postulated to be tested by such an investigation. For example, landfill pit size may relate to the capital and operating costs for the site. However, landfill costs are dependent on other factors such as location of the site (which influences purchase cost) and the local geology (which influences engineering and operating requirements). The unique nature of individual landfill sites could be explored on a case by case basis if

Fig 9.10: Indifference Lines for Scenario 7 - different sizes of landfill site

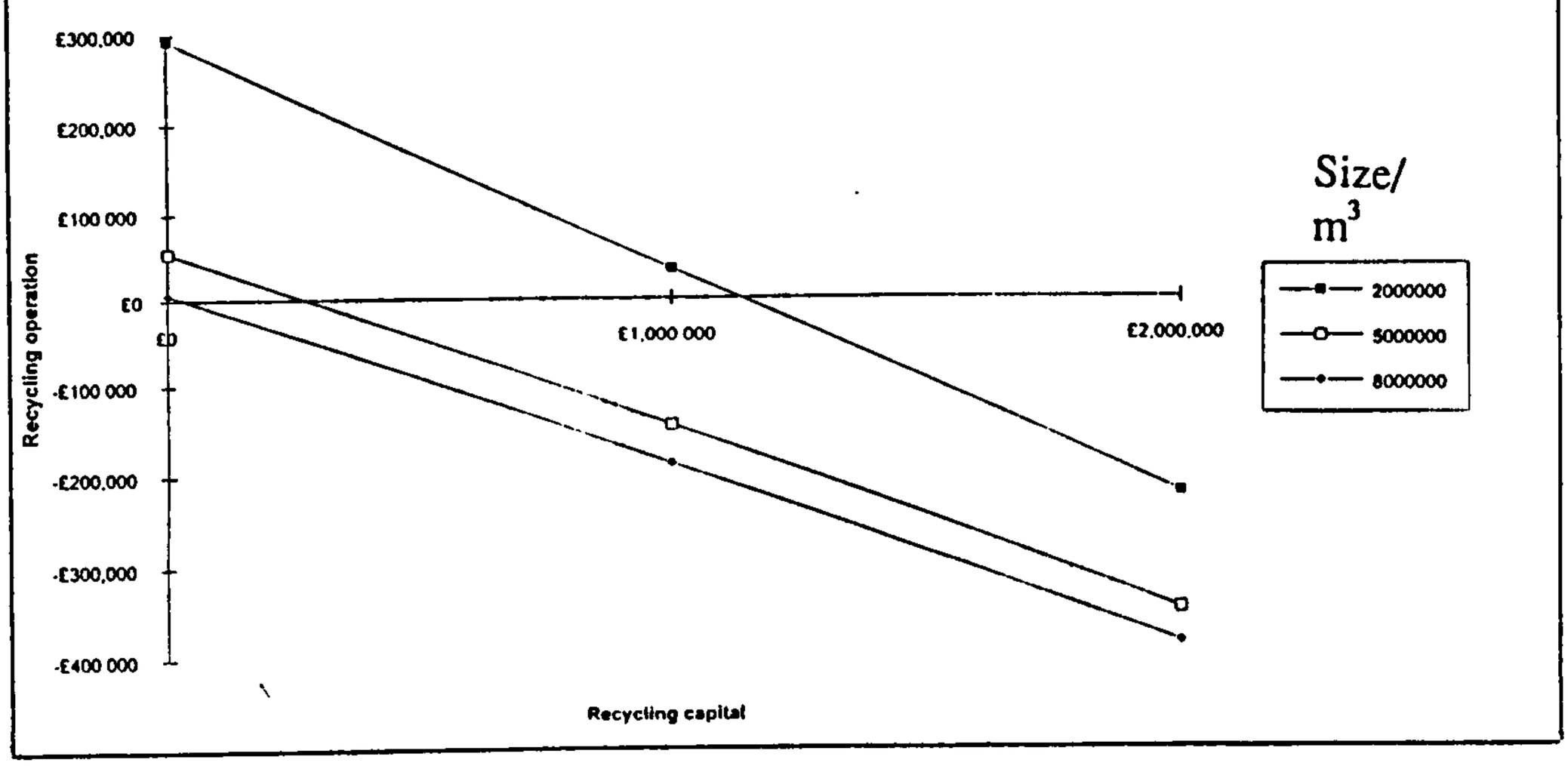
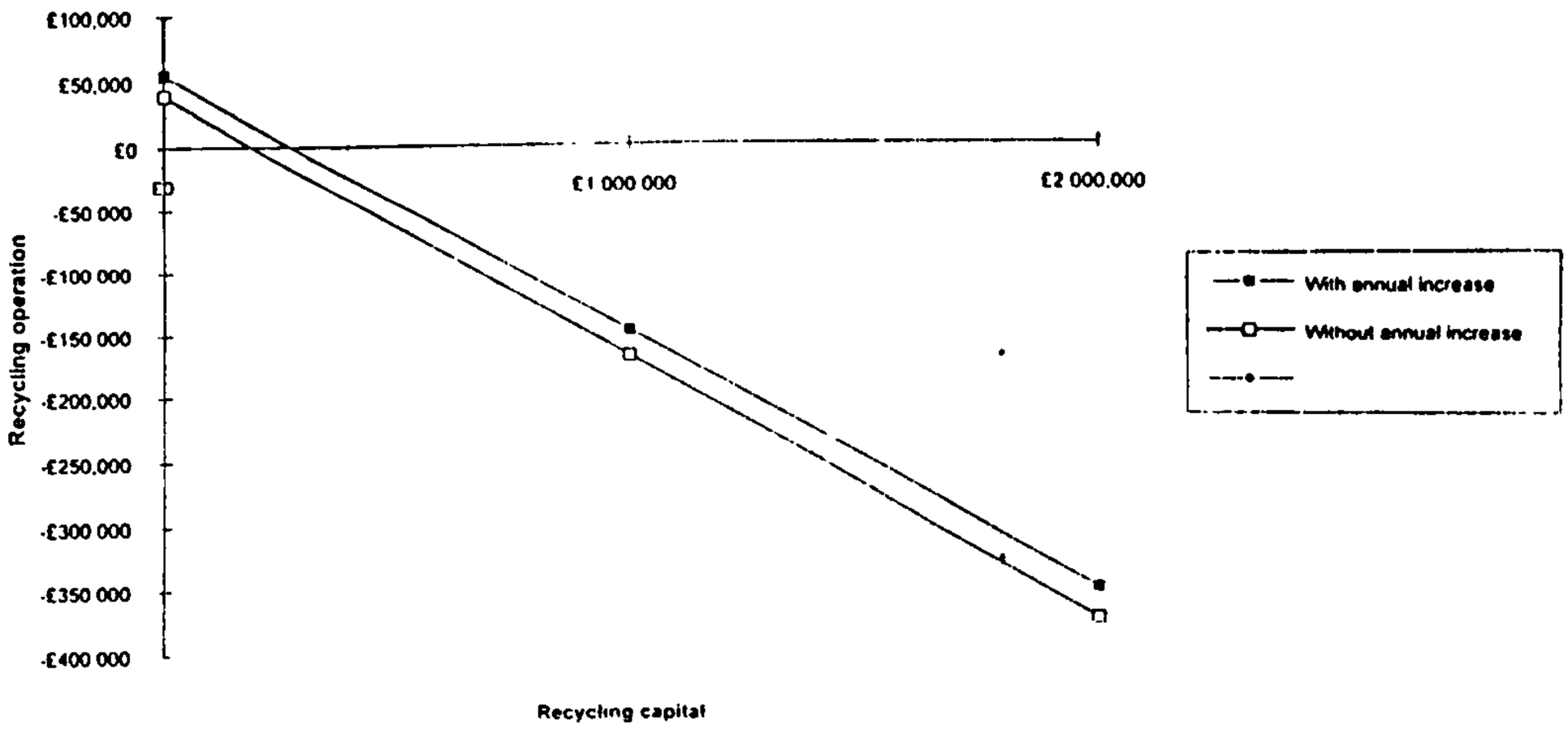


Fig 9.11 Indifference Lines for Scenario 8 - with and without annual cost and revenue increases



data for more sites were available (in which case many variables would be changed). However, such an investigation would focus more on implementation of recycling at particular facilities rather than the general conditions which influence recycling.

9.5 Analysis of Model Results

The lines of indifference generated for each scenario show how the viability of recycling is influenced by different conditions. The results of the scenarios are summarised in Table 9.6. From this table the following observations may be made:

Recycling is "encouraged" as values altered in scenarios are increased if;

values for "OR at KR=0" increase (the indifference line moves upwards along the recycling running cost axis)

and line gradient remains constant or becomes less negative (the indifference line becomes less sloped with respect to the recycling capital cost axis)

and CNPV increases or remains constant (profits are only increased).

Conversely, recycling is "discouraged" as values altered in scenarios are increased if;

values for "OR at KR=0" decrease (the indifference line moves downwards along the recycling running cost axis)

and line gradient remains constant or becomes more negative (the indifference line becomes more sloped with respect to the recycling capital cost axis)

and CNPV decreases or remains constant (profits are only reduced).

Table 9.6: Summary of Model Output

Scenario	See Fig	Input Values	Site CNPV	Indifference Line:- OR value at KR=0	Indifference Line:- Gradient
1	9.4	OL = £500,000	£5,922,299	£63,187	-0.20
		OL = £750,000	£4,823,933	£55,322	-0.20
		OL = £1,000,000	£3,725,637	£47,457	-0.20
2	9.5	OL = £500,000	£4,809,616	£23,451	-0.21
		OL = £750,000	£3,711,319	£20,340	-0.21
		OL = £1,000,000	£2,613,023	£17,228	-0.21
		(NB Input Aggregation 1 is used)			
3	9.6	D = 8%	£13,749,823	£193,458	-0.10
		D = 15%	£7,284,522	£96,472	-0.16
		D = 20%	£4,823,933	£55,322	-0.20
4	9.7	D = 8%	£11,769,271	£63,924	-0.11
		D = 15%	£5,965,620	£33,552	-0.16
		D = 20%	£3,711,319	£20,340	-0.21
		(NB Input Aggregation 1 is used)			
5	9.8	Default Input	£4,823,933	£55,322	-0.20
		Input Aggregation 2	£4,158,670	£58,095	-0.20
		Input Aggregation 3	£3,369,590	£114,548	-0.20
6	9.9	RY = 0	£4,823,933	£55,322	-0.20
		RY = 5	£4,823,933	£109,929	-0.23
		RY = 10	£4,823,933	£187,366	-0.31
7	9.10	S = 8,000,000 m^3	£5,378,415	£6,455	-0.19
		S = 5,000,000 m^3	£4,823,933	£55,322	-0.20
		S = 2,000,000 m^3	£1,969,938	£292,964	-0.26
8	9.11	With Annual Cost Increases	£4823,933	£55,322	-0.20
		Without Annual Cost Increases	£4,312,340	£39,330	-0.21

Variables which (due to increases in value) encourage the recycling option include:

TS - Throughput percentage for skips (compare Scenario 2 and Scenario 1)

Annual increases for costs and revenues (Scenario 8)

Variables which (due to increases in value) discourage the recycling option include:

OL - Operating cost for the landfill (Scenario 1)

D - The discount rate used (Scenario 3)

TC, TH and TO - Throughput percentages other than for skips (compare Scenario 2 and Scenario 1)

Equation 9.4 (Section 9.3) suggests that recycling is preferable on more profitable landfill sites.

Given that rates of revenue increase exceed rates of running cost increase, this explains why accounting for cost increases encourages the recycling option.

Similarly higher operating costs reduce profit and so they discourage the recycling option.

The recycling option is more viable on more profitable landfill sites (more profitable than other sites compared without considering recycling) because the benefit of extending site lifetime is greater for more profitable sites.

A high discount rate means that higher rates of annual profit must be achieved to make a project attractive. Also the higher the discount rate, the more benefit is acquired from such profits sooner rather than later. Since the recycling option accrues profit for the landfill operator over a longer time period, its perceived viability is highly dependent on the operator's discount rate.

Increasing skip throughput (which reduces the percentage of other throughputs) enables more recycling to take place and so increases the amount of time by which pit lifetime is extended. This enables the profitability of the landfill site to be extended over a longer time period.

The viability of the recycling option is improved under the following three kinds of conditions:

More profitable landfill sites (when sites are compared without considering recycling)

Less need for rapid return on investments (represented by low discount rates)

Increased amounts of materials sent to the landfill site for recycling

The third condition refers to high throughput without reducing the price charged for builders' waste. This may be considered when selecting a site to implement recycling. For example, sites nearer to urban areas or major construction activities are likely to receive more construction waste.

Scenario 5 is interesting since the decrease in price charged for skips (those containing construction waste) from £8 to £4 has very little effect on the viability of the recycling option compared to the reduction from £4 to £2. This is despite the fact that each reduction is modelled to generate a similar increase in throughput of skip waste (an increase by an amount equal to half the default

throughput in each case). This is because landfill catchment is related to price charged in a non-linear way. It should be noted however that in each case, the price reductions result in decreased CNPV of the site. This suggests that price reductions are not justified since they result in reduced profits. This is not surprising since BCWM as professional Waste Managers are likely to be charging near to optimum rates for wastes. Scenario 5 suggests that if a landfill site experiences markets for skip waste that do support price reductions in the interest of increasing throughput (ie if CNPV is not reduced when prices are reduced) then recycling is encouraged. Although increased throughput of skip waste generally improves the viability of the recycling option, this should not be at the expense of revenue losses which are not compensated for by increased sales.

Scenarios 6 and 7 generate indifference lines which fit none of the conditions for "encouraging" or "discouraging" the recycling option. Whereas other scenarios showed that increases in given variables encourage or discourage the recycling option regardless of the capital and operating costs of the recycling option, these two scenarios show a dependence on the recycling costs.

For low values of recycling capital cost, small landfill pit size and later implementation of the recycling option improve the viability of the recycling option (higher operating costs can be afforded). For high values of recycling capital cost, the converse is true.

The common feature of both scenarios is that the variables changed affect the amount by which recycling increases the lifetime of the landfill pit. In both cases, reduction of the amount of time by which recycling extends pit lifetime can favour lower capital cost and higher running cost recycling options whilst increasing the amount of time can favour recycling options with higher capital costs and lower running costs.

These results show that the consequences of capital and running cost values for the recycling operation for the viability of the recycling operation are dependent on the amount of time by which the recycling operation extends pit lifetime. Higher capital cost options tend to require longer lifetime extensions than lower capital cost options.

9.6 Conclusions for Recycling Construction Waste at Landfill Sites

According to the model, the viability of recycling construction waste into hardcore and cover material at a landfill site is dependent on;

The profitability of the landfill site without recycling

The rate of return on investment desired (the discount rate)

The quantity of construction waste available for recycling as long as increased quantity is not due to decreased revenue (as occurs if prices are reduced below optimum levels)

A trade off between capital and operating costs for the recycling operation which is dependent on the amount of increase in pit lifetime which the recycling option enables (which is in turn dependent on the amount of construction waste recycled).

The recycling option does not increase revenue for the landfill site unless higher prices can be charged for established sources of hardcore and cover materials.

The costs of site closure and aftercare remain small despite recent high rates of increase. The recycling option does not generate significant benefit due to delaying appreciation of these costs.

In this case study, the primary benefit of the recycling option is that it enables landfills to continue making profit by landfilling other wastes in place of those removed by recycling as the pit lifetime is extended by two to ten years.

The model was applied to recycling construction waste. However, recycling any form of waste would enable landfill sites to remain in use for longer and would yield similar kinds of benefit. In this case revenue from resale of recycled materials was negligible which is unsurprising from a low grade material source such as construction waste. Applying a similar model to other waste streams may require account to be taken of resale opportunities.

The very significant effect of discount rates in the analysis, highlights two issues:

Recycling to extend landfill pit lifetime is a long term investment and viability is increased if lower discount rates are applied.

Given that firms employ higher discount rates than governments, then firms are less likely than governments to pursue the kind of recycling activity investigated. This situation could be addressed by some form of subsidy or mandatory requirement imposed on landfill operators.

The model presented does not account for the fact that if a landfill operator seeks to maintain a given number of working sites then the benefit of extending site lifetime is increased. The model did not account for any need to open a new site and incur high capital costs at the time of site closure. Recycling which extends the lifetime of landfill sites delays the appreciation of such costs. The model could be developed further to be used to asses a sequence of landfill investments to enable effects of increasing capital costs to be analysed.

9.7 Conclusions for Recycling in General

In the case modelled, benefits due to lifetime extension of landfill sites are significant. Viability of recycling waste which has a high value (as a waste or a recycled material) to weight ratio is likely to depend more on revenue effects than on benefits due to extending landfill site lifetimes. The model presented can account for such revenue effects by including a resale value for recycled materials in the calculation of contribution to revenue of recycling (variable "RR"). Such options

may include recycling abated emissions (expensive as wastes) or metals (valuable materials).

Other options may have similar contributions in terms of extending lifetime of landfill sites. For example, incineration to reclaim energy from materials with high calorific content (paper, plastics, cardboard and wood) reduces the volume of waste dramatically. Such options are often considered in terms of benefits from energy sales. However, recent increases in landfill costs and profits may make benefits due to extending site lifetime appreciable.

Some recycling options may present costs and benefits which are not obviously quantifiable. For example, recycling or incinerating abated pollutants rather than landfilling them may reduce pollution arising from the landfill site. Recycling any waste may enable vehicles delivering such waste to experience faster turn around times and thus attract more business to landfill sites without having to reduce prices.

The model demonstrates that many conditions are particular to individual sites. The model is useful for identifying the kinds of sites at which recycling is more likely to be viable, such as;

Sites which receive the largest volumes of waste to be recycled

Sites which are the most profitable (if lifetime extension is significant)

However, for any site for which recycling is to be considered the model may be simplified. There is no need to consider indifference lines if recycling capital and operating costs are available. It would be simpler to consider CNPV as represented in Fig 9.3 for an individual run of the model. This enables the amount by which recycling may contribute to profit to be assessed rather than if it is viable or not. Model variables should be adjusted for the individual site to test for sensitivity since variations in individual variables can be more significant for different sites. For example differences to site operating costs are more significant in Scenario 1 than in Scenario 2.

9.8 Conclusions for Waste Policy Formulation and Implementation

This chapter commenced by identifying particular attributes of Waste Managers which may make them candidates to develop recycling infrastructure.

Firstly, the regional planning remit of Waste Regulation Authorities is suited to recognising benefits of recycling due to reductions in pollution encouraged by changes to resource supply and reductions in disposal. In the case examined, the waste stream concerned is not particularly polluting and may present little opportunity to exploit such benefits. However, the planning remit of WRA's does include an imperative to ensure continued provision of waste disposal facilities for wastes arising within their region. Recycling options which extend the lifetime of disposal facilities can contribute to this end. By increasing the lifetime of existing waste disposal facilities, recycling can reduce the frequency with which WRA's may license new sites and contribute to alleviating public concern since, eventually, less sites will have to opened to satisfy local needs.

Such benefits would be dependent on reduced need for landfill as a form of land reclaimation. This would require reductions in resource extraction in the region, perhaps as a consequence of waste minimisation in the construction sector.

Another reason why recycling may contribute more at the regional level is considered in Chapter Six in terms of material balancing within regional boundary conditions. Recycling can also contribute to reducing the need for import or extraction of resources for a region.

In the case considered, the recycling option replaces source separated hardcore and soils with processed materials which are of a lower grade (they may contain wood chips or shredded materials other than stone or soil). Resource use benefits can only be exploited if an alternative use for higher grade soils and hardcore is identifiable. If an alternative use is found then there may be a reduced need for import or extraction (which may cause environmental harm).

In Chapter Seven, it is shown that the construction sector is limited by quality requirements (of regulators and customers) which may preclude such materials being used in many cases. However there may be cases for which structural integrity demands less stringent quality requirements for materials such as use in car park foundations. Other sectors may also be able to use some materials. For example source separated soils may be useful as agricultural topsoil.

In the Anglia region several regional planning agencies have prepared a strategic plan which calls for more recycling of construction materials, especially for use in building flood defences.

Identification of such opportunities by Waste Managers may provide them with some lobbying power with WRA's and enable them to exploit some broader benefits of recycling. In the case of recycling construction waste there is a convenient link between landfill sites and quarries since quarries provide the material recycled and disused quarries are often reclaimed by landfilling. The benefit of recycling construction waste at the regional level is emphasised since reduced need for quarrying is supported by replacement of quarried materials with those no longer landfilled and by a reduced need for disused quarries to be used as landfill sites.

Whether WRA's are receptive to lobbying based on this kind of benefit depends on the weighting WRA's give to regional issues compared to those associated with direct licensing of landfill sites. Although this issue is not pursued in this research, it does illustrate the nature of the problem inherent in the new regime which devolves Waste Policy formulation and implementation from governmental control to include industrial agencies such as Waste Managers.

A second reason why waste managers may be candidates to implement recycling options is that the majority of waste management firms are well resourced and progressive. The modelling activity presented in this chapter illustrates that development of recycling facilities involves consideration of long term effects. Waste management firms posses the kinds of skills required to develop large scale projects and have access to capital in sufficient quantity to enable viable options to be developed. However, waste management companies do, like many large Industrial Agencies, expect considerable returns on investment. The relatively large discount rate of 20% used in most of the model runs reflects high expectations of Waste

Managers regarding investments which is unsurprising given the profitable nature of the waste management industry.

A similar model to that presented in this chapter could be used to identify appropriate values for subsidies for a given case of recycling. For example, in the case modelled by Scenario 1 if recycling capital costs are around £M2 then a subsidy of the order of £350,000 per annum or £M1.75 as a capital grant would serve to make recycling just as viable for a waste management firm using a 20% discount rate as it would be for a governmental agency employing an 8% discount rate (see Fig 9.4).

The use of subsidies in this manner is clearly at odds with the market based approach to the polluter pays principle currently adopted by the UK Government. In terms of Wolbeck's idea of comprehensive development of waste options, a subsidy approach also begs questions regarding other options, such as waste minimisation, that present similar regional benefits and which involve long term investments by Waste Producers. Such options would require similar treatment if a subsidy policy were to be implemented fairly.

The third reason given in Section 9.1 that suggests Waste Managers may be well positioned to develop recycling infrastructure is that they are aware of differences between wastes in terms of particular problems arising during waste treatment and disposal. For example, Waste Managers are able to judge recycling options in the context of benefits they as Waste Managers may appreciate. Although waste minimisation may also enable landfill sites to remain open for longer, this benefit is not experienced by Waste Producers.

Conversely, Waste Managers may not accrue all the benefits of recycling. If for example, a Waste Manager implements an option to recycle abated pollutants, this option may benefit smaller waste producing firms that are unable to find alternative waste facilities for abated pollutants which they can afford and that are unable to implement waste minimisation options due to lack of resources.

In summary, this chapter concludes the case study of recycling construction waste by presenting a model which is useful for;

> Identifying conditions experienced by Waste Managers which influence the viability of recycling construction waste. Such conditions may also apply to other recycling options which share similar characteristics.
>
> Identifying issues relevant from the Waste Manager perspective for Waste Policy formulation and implementation.

In Chapter Ten, the findings of research presented in this thesis are considered in the general context of Waste Policy formulation and implementation involving many agencies and the consequences of these findings are discussed in the context of Sustainable Development.

CHAPTER TEN

Implications of The Research

Nor is it only proper we should in general indulge our inclination in the most elaborate philosophical researches, notwithstanding our sceptical principles, but also that we shou'd yield to that propensity, which inclines us to be positive and certain in ***particular points****, according to the light, in which we survey them in any* ***particular instant.***

(D. Hume 1740: "A Treatise of Human nature" Book I Part IV Section VII)

10.1 Introduction

This thesis builds on the work of Wolbeck (Wolbeck 1977) who identified the need for a "comprehensive approach" to Waste Policy which is cotenable with the view of other authors who have addressed recycling and Waste Policy issues. Wolbeck identified the need for more information about waste in order to coordinate the "multiplex" interests of individual plants. The research presented in this thesis is structured by a conceptual model which inherently presumes complex interactions between multiple agencies. This means that consequences of activities controlled by a given agency can feed back via responses of other agencies to influence the control parameters of the original agency.

For example, a firm may implement environmental improvements on the basis of their confidence that competitors will be forced to achieve similar levels of improvement. If the firm is experiencing particularly good conditions for implementing change (eg during design of new plant) then it may expect that competitors will experience difficulty meeting standards achieved. However, in some sectors, regulatory agencies may be lenient on firms operating existing plant, or in some areas, Local Authorities may be lenient on large local employers. In such sectors, the confidence of progressive firms (a control parameter in this case) may be diminished.

The complexity inherent in the conceptual model (which is used to direct and interpret research) enables complex issues apparent in the real world to be recognised and represented. The technique of loosely structured interviewing is appropriate for identifying complex issues, since the information generated is diverse and hence more likely to identify broad ranging effects that may form part of a complex chain. It is possible to gather more structured information about complex issues once the issues are identified using techniques like questionnaire surveying. Such research would be complementary to this thesis.

The idea of considering multiple perspectives for investigating policy issues is not new. Indeed, wherever issues are complex due to control parameters of different agencies or constituencies such an approach would seem to be essential if complexity

of phenomena is to be captured in data. The particular perspectives selected in this thesis are chosen to capture data pertinent to the new process of Waste Policy formulation and implementation which involves Legislative and Industrial Agencies. Two types of Industrial Agency (Waste Producer and Waste Manager) are selected to capture data pertinent to external recycling which necessarily involves more than one Industrial Agency. Alternative perspectives could be selected to focus the research on other issues as would be appropriate for further development of research presented in this thesis.

The fact that the perspectives chosen are not exhaustive of all relevant perspectives suggests that the system researched is "open" as well as complex. This means that not all issues identified in the research are resolvable in terms of conditions and decision criteria pertinent to the limited set of perspectives. Furthermore, the agencies involved are "human" which means that their behaviour in the real world may not be according to any set of definable axioms. This may be because behavioural science is not sufficiently developed to perform such a reduction or because humans behaviour includes an element of "free will" which can never be accounted for by axiomatic principles.

That this research focuses on "complex, open, human, systems" means that the research findings are non-predictive, inexhaustive and incomplete reductions of human behaviour. Conclusions of this research then must focus on;

description rather than prediction

contribution of evidence rather than final judgement

and relevance of observed human factors rather than behavioural analysis

Such conclusions are useful for identifying why Waste Policy formulation and implementation is as it is the UK. The factors which make it so in the real world are shown to be complex. For further development of Waste Policy, it should be borne in mind that, as with any complex issue, there is no necessarily justifiable strategy. The best strategy for any agency depends on the strategies of other agencies involved. The new regulatory regime actively encourages involvement of more agencies in Waste Policy issues which makes determination of strategy for Legislative Agencies dependent on the strategies commonly used by Industrial Agencies. The implications outlined below are informative in respect of identifying the issues generated in the new regime and the strategies currently in place. Future changes to Waste Policy by any agency would be well informed by these implications although particular determination of strategy should be informed by other contributory evidence relevant to conditions not explored in this thesis.

10.2 Implications for Understanding of Recycling and Waste Policy

Historical analysis of recycling and Waste Policy has focussed on Sustainability in national and international contexts and on recommendations for Governments to impose particular types of practice on industry. In terms of the material balancing

model used in this thesis, such an approach can be considered in terms of national boundary conditions for material balancing which demonstrate that recycling options present similar benefits to waste minimisation options.

In a historical context recycling presented an opportunity for Governments to improve environmental performance of industry with minimum degrees of intervention. Subsidy of recycling infrastructure requires less involvement with firms than would be required for stipulation of process technology to be employed. Recycling was perceived as something which industry would not develop of its own volition and which therefore required governmental sponsorship.

In the modern domain, the situation is reversed since the regulatory style is better suited to encouraging firms to apply their own resources in the most appropriate manner for the conditions they face. This situation is a less favourable environment for developing recycling infrastructure than historical regimes have generated but the reason is the same!

Recycling options are less directly associated with the immediate interests of waste producing firms. In a historical context this made promotion of recycling an easy form of intervention, since it required less change on the part of industrial firms. In the modern context, firms are motivated to develop improvements in-house in order to gain competitive advantage. Recycling options are less popular because in-house resources of firms are not well suited to developing external infrastructure and because competitive advantage is not appreciated if recycling infrastructure is accessible to competitors.

Despite the change in regulatory style, similar problems of environmental accounting are as apparent today as they were to Anderson (Anderson 1977). Anderson recognised a problem which in the historical context was associated with governmental sponsorship of resource extraction and processing and waste management infrastructure and he argued that recycling should be sponsored to a similar extent. In the modern regime there is a failure to account for environmental problems associated with industrial operations along material streams. Waste Producers are not accountable for pollution arising from resource extraction and processing associated with materials used or for pollution arising from management of wastes produced. The problem today is not one of how much to sponsor but how much to make polluters pay.

One new phenomena is regulation using emission standards continually tightened according to BATNEEC and BPEO principles. Pearce (Pearce et Al 1989) identified the problem of accounting for environmental effects in economic terms and suggested that a subjective stipulation based on current value judgements was the way towards sustainability. The modern principles of BATNEEC and BPEO can be considered as determining a yardstick for environmental accounting. A scale of appropriate environmental standards is calibrated according to perceptions of the best that can be achieved. Of course the definition of "best" remains open to subjective interpretation and is likely to be dependent on perceived threats to Sustainable Development as defined by political, social and personal values of the day.

Wolbeck's argument (Wolbeck 1977) that waste minimisation, material substitution, abatement and waste management and recycling should be comprehensively developed in the interest of Sustainable Development is as true in the modern regime as it was historically. In the modern context (in the UK), the governmental role in determining a comprehensive blend of options is diminished in the interests of motivating Industrial Agencies to play a larger role by exploiting their particular expertise regarding industrial processes. This change of emphasis has led to a shift from recycling options towards organisationally internal options such as waste minimisation. A new imperative is that Waste Policy be developed coherently as well as comprehensively. In other words, the actions of individual agencies when considered together must be conducive to objectives of Sustainable Development as well each agency pursuing a comprehensive approach from its own perspective.

The modern regime of regulation does focus more strongly on environmental protection than on resource conservation. This may pose a problem in as much as resource extraction activities are regulated to reduce environmental degradation. Indeed, the historical focus on resource conservation as an element of Sustainable Development expounded by Wolbeck may have been associated with a perceived value in "positive preparedness". This term reflects a desire to maintain national self sufficiency in the event of war or resource crisis. That current Legislative Policy seems to relegate resource issues may reflect a new confidence in stability of world markets for resources. Even if this confidence proves to be well founded and environmental quality is the primary concern, it should be remembered that Sustainable Development involves consideration of pollution at an international level and that some sources of imported resources may not be from sustainable sources. In the event that standards of resource extraction and processing are improved in developed countries there may be even more need to ensure that materials are not imported to exploit high prices charged for sustainable materials whilst also exploiting the environments of countries which are less able to regulate effectively. Ultimately the environment is shared internationally and consequences of local pollution may eventually be borne by the international community.

10.3 Critique of Method and Summary of Findings

The domain of the research presented in this thesis is the modern context of UK industrial regulation which is characterised by a distribution of responsibility between Industrial and Legislative Agencies ("Industrial Agencies" are commercial organisations. "Legislative Agencies" are governmental organisations that draft legislation and those empowered by legislation to regulate firms). The contributions of research activities presented in preceding chapters are represented in Fig 10.1 in terms of the subject area each chapter covers in the context of the conceptual model presented in Chapter Three.

The review of legislation presented in Chapter Four identifies legislative tools, principles and objectives pertinent to Waste Policy in the UK. This research relies strongly on literature sources. The current popularisation of

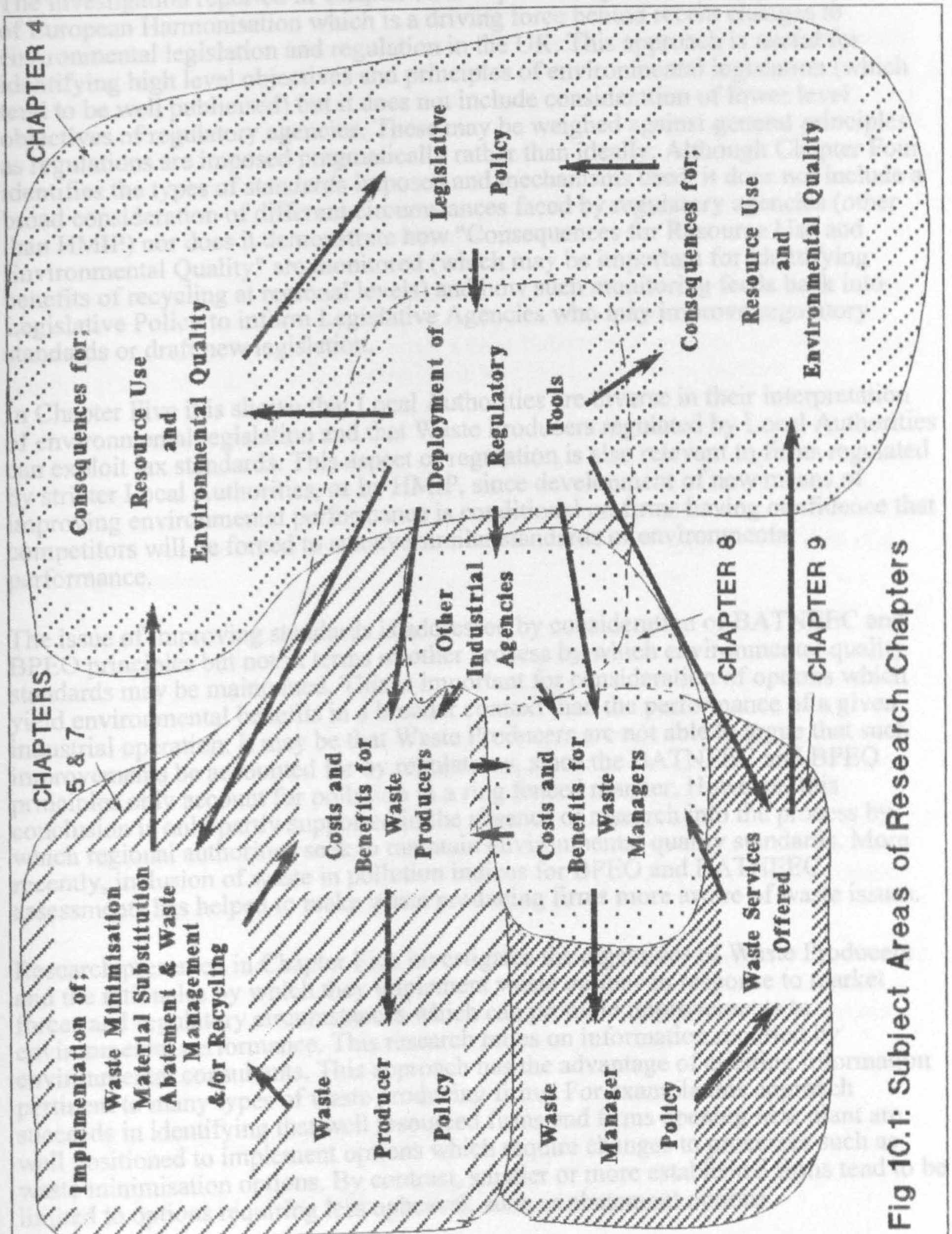


Fig 10.1: Subject Areas of Research Chapters

environmental and European issues and their consequences for industry in the UK has led to a wealth of published information to draw on in this respect.

The investigation reported in Chapter Four explores Legislative Policy in the context of European Harmonisation which is a driving force behind recent changes to environmental legislation and regulation in the UK. This approach is useful for identifying high level objectives and principles of environmental legislation (which tend to be well publicised) but it does not include consideration of lower level objectives of regulatory agencies. These may be weighed against general principles as regulations are imposed pragmatically rather than ideally. Although Chapter Four identifies the types of standards imposed and mechanisms used, it does not include a broad consideration of different circumstances faced by regulatory agencies (other than HMIP) nor does it demonstrate how "Consequences for Resource Use and Environmental Quality" are monitored (which may be important for identifying benefits of recycling at regional levels) and how such monitoring feeds back into Legislative Policy to inform Legislative Agencies who may improve regulatory standards or draft new legislation.

In Chapter Five it is shown that Local Authorities are diverse in their interpretation of environmental legislation and that Waste Producers regulated by Local Authorities can exploit lax standards. This aspect of regulation is also relevant to firms regulated by stricter Local Authorities, or by HMIP, since development of new means of improving environmental performance is conditional on firms having confidence that competitors will be forced to achieve similar standards of environmental performance.

The issue of improving standards is addressed by consideration of BATNEEC and BPEO principles but not in terms of other process by which environmental quality standards may be maintained. This is important for consideration of options which yield environmental benefits in a broader context than the performance of a given industrial operation. It may be that Waste Producers are not able to argue that such improvements be accounted for by regulations, since the BATNEEC and BPEO principles only account for pollution in a ring fenced manner. However, this conclusion is only partly supported in the absence of research into the process by which regional authorities seek to maintain environmental quality standards. More recently, inclusion of waste in pollution indices for BPEO and BATNEEC assessments has helped to make waste producing firms more aware of waste issues.

Research presented in Chapter Five investigates the objectives of Waste Producers and the rationales by which they implement waste options in response to market forces and regulatory circumstances which can promote improvements to environmental performance. This research relies on information reported by environmental consultants. This approach has the advantage of eliciting information pertinent to many types of waste producing firms. For example this approach succeeds in identifying that well resourced firms and firms opening new plant are well positioned to implement options which require changes to processes such as waste minimisation options. By contrast, smaller or more established firms tend to be limited to options requiring less upheaval, such as abatement options.

However, environmental consultants may tend to exaggerate the importance of environmental issues to Waste Producers. In contrast, research findings presented in

Chapter Seven suggest that environmental concerns are subsidiary to concerns about product quality for a construction firm. The breadth of information presented in Chapter Five may be at the expense of detail regarding other issues faced by firms and the relative importance attached to environmental issues.

The research presented in Chapter Five could be complemented by further research into the priorities of firms and the extent to which environmental issues are considered important. The research conducted suggests that firms are diverse in this respect due to different conditions which firms experience. Further research could be conducted to elicit information directly from firms about the particular conditions they experience, the kinds of environmental improvement they pursue and the benefits they anticipate from such improvements. A questionnaire or interview approach would be appropriate for such an exercise.

The limitations expressed above are due to a restricted depth of investigation in the areas researched. However, the research is also limited, in terms of the breadth of investigation, to only three perspectives. Other Industrial Agencies that seem to play important role in Waste Policy formulation and implementation include;

Technology Suppliers - Suppliers of plant and equipment seem to trade off environmental characteristics of performance with quality requirements and the price which purchasers are prepared to pay. The role of Technology Suppliers could be investigated to determine how much the environmental performance of industry is limited by availability of appropriate plant and equipment.

Material Suppliers - The option to substitute materials is not as well investigated as other waste options in this thesis, largely because such an investigation would require research into the behaviour of Material Suppliers. Material Suppliers may also exploit opportunities to recycle materials although they may be limited by quality specifications of their customers, availability of secondary materials to recycle or regulatory requirements to limit pollution despite external benefits which recycling may present. Investigation of Material Suppliers would also allow environmental problems associated with established sources of materials to be considered alongside potential benefits of recycling, material substitution or waste minimisation due to reductions or changes in resource use.

There are many Legislative Agencies in the UK which are involved in Waste Policy formulation and implementation. Only HMIP and WRA's have been considered in any depth in this thesis although issues associated with Local Authorities are also recognised. Other Legislative Agencies which can play a significant role in regulation of pollution or wastes include:

The National Rivers Authority

The Nature Conservancy Council

The Health and Safety Executive

The National Heritage Commission

Each of these agencies can play a significant role through consultation with Legislative Agencies directly responsible for environmental regulation, or by regulating industry according to their own particular remits so as to influence industrial practices regarding waste. An investigation could be conducted in parallel with research into regional regulation to maintain quality standards since many of these agencies operate on a regional basis.

The material balancing model presented in Chapter Six represents many of the issues arising from the findings of Chapters Four and Five. The material balancing model distinguishes waste options in a way which allows them to be considered in terms of;

Legislative objectives - by using boundary conditions appropriate to different objectives

Regulatory tools and industrial objectives - by considering costs associated with materials inputs and outputs and with process changes which are increased or decreased according to regulatory mechanisms employed.

Implementation of waste options - by considering interactions with external agencies and internal skills required for firms to implement different types of option.

That regulatory mechanisms and costs appreciated by firms can be represented in a similar fashion reflects the market based approach adopted by Legislative Agencies in the UK. That the particular costs and mechanisms identified are associated mainly with emissions and wastes, reflects the focus of environmental regulation on limiting pollution at source and containing wastes in disposal facilities (through improvements in waste management, the cost of which is passed to Waste Producers).

A similar approach could be used to consider findings of investigation of Material Suppliers to compare pollution arising from resource processing and extraction and that arising from resource use. It may also be interesting to consider material balancing from a Technology Supplier perspective. However, it should be borne in mind that resource and pollution effects arising from manufacture of plant and equipment are probably secondary to the effects that new plant and equipment can have in use.

The material balancing model presented in Chapter Six does not represent all the research findings of Chapters Four and Five. A more sophisticated model might also represent attributes such as firm size, age of plant, or account for regulatory mechanisms in more detail than simply considering increasing or decreasing costs appreciated by firms. Development of such a model would require further economic analysis of the situation of firms as would be appropriate if further research were conducted into Waste Policy formulation and implementation in waste producing firms.

Phase One of the research (Chapters Four and Five) was designed to identify detail of the real world pertinent to the systems conceptually modelled in Chapter Three. Research questions were used to map research findings onto appropriate elements of the conceptual model. However, the research findings also suggested that issues in the real world regarding Waste Policy formulation and implementation were not representable as groups of attributes interacting en masse with other groups of attributes as would be the case if such a mapping were performed. In fact, the issues identified arise from subsystems which operate at a finer level of detail than that resolved in the conceptual model. Sub-system elements influence elements of other sub-systems sometimes feeding back to influence other elements in the original sub-system. In other words, the issues identified in the real world are more complex than the conceptual model can easily represent.

However, the material balancing model presented in Chapter Six does represent issues associated with Waste Policy formulation and implementation which were identified in Phase One of the research. In consideration of legislative aspects the materials balancing model is used with the conceptual model as a framework within which to consider boundary conditions appropriate to given legislative objectives. In consideration of industrial aspects, the materials balancing model is usually applied within boundary conditions of a firm.

Although many issues arising from interpretation of research findings in terms of material balancing are outlined in Section 6.5 only one of these is explored in depth by the case study conducted as Phase Two of the research. Other issues could be investigated by conducting further research of the types outlined above.

Research presented in Chapter Seven explores a similar area in terms of the conceptual model as that presented in Chapter Five. However, Chapter Seven considers the particular case of a construction firm rather than the general case of waste producing firms. Detailed investigation of one firm, which is progressive regarding Waste Policy, successfully identifies issues and problems faced by construction firms and the kinds of waste option implemented in the construction sector. This is appropriate since the general investigation presented in Chapter Five does not identify how different conditions faced by firms relate to different industrial sectors.

The investigation presented in Chapter Seven is limited by consideration of one firm only. Although evidence is presented which demonstrates that other firms experience similar kinds of conditions to those presented in Chapter Five (eg smaller firms in the construction sector tend to be less progressive) many issues can only be recognised in Chapter Seven rather than analysed in the particular context of the construction sector.

Chapter Seven does demonstrate that in consideration of particular recycling options, it is appropriate identify the particular conditions applicable to firms that supply waste. In the case examined, final users of recycled materials are waste managers so there was no need to conduct a similar activity to examine conditions faced by potential users of recycled materials as may be appropriate for an investigation of other recycling options. This research showed that the construction firm surveyed does, like Waste Producers in general, tend to focus internally when considering Waste Policy, resulting in a strong emphasis on waste minimisation type options for

change. One exception is noted (separation of compressible wastes) which is exemplary of the amount of effort which options involving external interactions with other firms tend to require.

The research presented in Chapter Seven identified Waste Hauliers as "Other Agencies" playing a significant role in Waste Policy formulation and implementation. The catchment model presented in Chapter Eight is designed to represent important aspects of Waste Haulier behaviour for operators of a landfill site. The model does not represent local factors which are important for waste haulage such as; location of customers and transport depots, the particular road network around a landfill site and the particular routes employed by Waste Hauliers. This simplification allows the model to be easily applied to any waste facility for which appropriate data regarding competing facilities and waste transport costs can be gathered.

By highlighting general properties of catchment areas for waste facilities, the model was also used qualitatively to represent general issues regarding source separation and pricing strategy relevant to Waste Managers. This use of the model depends on a simple three dimensional representation of price and transport costs which would be more difficult to extrapolate from a more complicated modelling approach.

The catchment model is limited firstly by not representing local factors and secondly by representing hauliers as seeking to minimise cost of waste delivery and disposal. More sophisticated models could be developed although additional complexity should be tailored to specific needs.

For example, regional planners or waste management firms may seek to improve understanding of landfill catchments in a given area in which case additional local detail would be appropriate. Further research into the behaviour of Waste Hauliers may be justifiable in terms of a need to understand how they transfer costs to waste producing customers. For example some hauliers may seek to reduce trip times and pass on any additional costs. The findings of such research could be usefully represented in terms of effects on catchment of waste facilities.

The model presented in Chapter Nine is designed to assess the particular option to recycle construction waste at a landfill site by comparison with the option of not doing so. Modelled cases of economic indifference under various circumstances are used to assess the types of condition likely to make the recycling option more or less viable. The conditions identified arise from the Scenarios selected for analysis which are chosen on the basis that they represent real conditions reported by Waste Managers and that they are likely to be significant.

The results of the model runs representing a given set of conditions are less significant than the analysis of how different conditions influence the viability of the recycling option. This is because landfill sites are diverse regarding each condition represented by model input variables. However, the types of relationship between variables expressed by the model are generally representative of landfill sites and the effects of changing variables indicate general conditions relevant to the kind of recycling option modelled.

In the case examined, the primary benefit of the recycling activity is identified as an extension of landfill working life, enabling profit to be accrued over a longer time. Revenue effects (ie sale of recycled products) are, in this case, negligible. The model could be employed though, to assess recycling options for which revenue effects are more noticeable. None financial benefits include; increased attractivity of sites to hauliers if recycling facilities are easily accessed, possible regional benefits if import or extraction of aggregates and soils can be reduced, possible improvements to success of licence applications if regional benefits are recognised.

The recycling assessment model can be altered to consider the case of a given landfill site and a fully costed recycling option so as to determine actual contributions to profit to be expected. This would be appropriate if a likely site were identified according to the general findings of Chapter Nine and if the very particular option to recycle waste at that site were to be modelled.

The findings of Chapter Nine are extrapolated to consideration of other types of recycling and waste management. This extrapolation is possible because the Phase One of the research provides information about how the construction sector may be particular in the context of wastes generally produced in industry. However, just as Phase One of the research is limited so the extrapolation of findings is limited. For example, consideration of regional benefits of recycling options in Section 9.8 is limited by a lack of research into regional planning regimes, the spatial interactions of waste and waste facilities and the polluting nature of waste in a given kind of facility.

10.4 Implications of the Research for Waste Policy Formulation and Implementation

Legislative Policy in the UK generates different styles of regulation of waste producing and waste managing firms. Many waste producing firms are regulated according to BATNEEC or BPEO principles in a ring fenced manner which does not account for broader benefits of options that reduce amounts or types of wastes produced or resources used. This style of regulation tends to promote options which are justifiable on the basis of internal considerations related to individually licensed plant.

One advantage of this approach is that it encourages progressive and well positioned firms to adopt progressive responses that can generate new forms of best practice which may be considered as enabling standards to be improved for similar industrial operations. In some sectors such firms may be confident that deployment of resources to improve environmental performance will be justified by competitors being forced by regulatory pressures and market forces (such as increased expectations of customers) to follow suit. Progressive firms may recognise opportunities because their own good resource base gives them an advantage in developing options which competitors will find more difficult to implement, or because of possible sales of technology or skills to competitors.
This advantage is limited in some sectors by the number of progressive firms which are able to develop best practices. In sectors where many firms are regulated by Local Authorities or where many firms operate plant which is not due for renewal or replacement, the confidence of progressive firms may be diminished because competitors are less likely to be forced to achieve higher standards.

One disadvantage of this regulatory approach then is that some sectors may not contain enough progressive firms such that firms have enough confidence to develop the best options for environmental improvement. For example, the chemicals sector is often reported as progressive due to; the severe regulatory attention paid to this sector, the involvement of large well resourced firms in the sector and the high environmental profile of the sector which allows progressive firms to market environmental improvements successfully. The construction sector tends to focus more on quality requirements since these are the focus of regulatory pressure and customer demand.

Another disadvantage of the approach arises from the practice of ring fencing which only accounts for immediate environmental effects due to emissions released from a licensed plant. It is this aspect of regulation which enables firms to appreciate environmental consequences of their operations in terms of immediate costs which can be addressed by applying resources which firms are most likely to be endowed with (those associated with the operation regulated). However, ring fencing fails to make firms accountable for broader consequences of their operations, such as pollution arising from resource extraction and processing or from the management of wastes they produce. Although resource and waste management costs are increasing due to stricter standards imposed for associated operations, these cost increases only reflect the cost of reducing emissions, or improving standards to a certain level. These cost increases do not reflect the pollution which arises even from the best managed waste management or resource processing operations (to do so would contradict the very principles of BPEO).

This situation is exemplified by the fact that abatement options contribute to satisfying regulatory requirements for waste producing firms as much as waste minimisation options do despite the fact that abated pollutants are never perfectly contained in waste streams and disposal facilities after collection. It is possible that a recycling plant could be licensed as part of an industrial process in which case emission reductions achieved by abating and recycling pollutants are appropriately accounted for and traded off against any emissions arising from the recycling plant (in this case the recycling option is internal to the process and is a form of waste minimisation). However, if the same plant were licensed as an external operation such benefits would not be recognised. Part I Section 7(2) of the Environmental Protection Act (EPA 1990) states that licences should be awarded on the principle that, where possible, release of harmful materials is prevented and that releases should only be allowed if there are no practicable means of prevention. As regulatory agencies acquire more information about emissions arising from waste streams, preventative action may be encouraged to limit the scope for abatement options.

This distinction is particularly important when recycling is considered as an infrastructural option. This would be so if one recycling option were developed to service many waste suppliers. This kind of recycling option is particularly appropriate for servicing firms that are limited to implementation of abatement options. Such firms may not have plant which is easily replaced or reconditioned to implement waste minimisation with the resources available to the firm. Abated emissions tend to be sent for disposal since there seems to be current shortage of appropriate recycling infrastructure.

Waste disposal organisations license their operations on the basis that they are fit and proper persons to prevent harm to the environment or human health. Licences may stipulate that certain waste be treated in a particular fashion, in which case additional costs are simply transferred to waste producing customers. There has been little development of diverse options for management of any kind of material once it has been destined to join "the waste stream". Given that use of emission standards to regulate waste producing firms was introduced in order to promote diverse and innovative solutions to environmental problems in a way which process standards did not, and given that waste management firms are currently regulated according to process standards, this lack of diversity is unsurprising.

The waste management sector though is becoming more and more dominated by larger firms which have the kinds of resources required to develop infrastructural facilities (such as landfill sites). The interest of BCWM in recycling illustrates that such firms consider development of recycling infrastructure to be justifiable in profitable cases. It remains to be seen whether large waste management firms can succeed in lobbying Waste Regulation Authorities so that regional benefits of recycling options can be accounted for to some degree in licensing provisions. However, such large firms do expect considerable returns on investment, and in the absence of government intervention to promote investment in recycling infrastructure, it is likely that only the most profitable recycling options will be developed.

The financial benefits of recycling have traditionally been associated with revenue effects due to taking materials with low or negative value (wastes) and converting them into materials with appreciable value. Research presented in Chapter Nine identifies that recycling options can also present benefits due to increasing the lifetime of established waste disposal facilities. Landfill sites are already costly and politically sensitive to develop and open and this is likely to continue into the future. Although capital costs are not significant for landfill operators that do not feel obliged to open new sites as existing sites close, the current climate in waste management suggests that the more professional firms are keen to continue developing capacity. Recycling then presents an opportunity to make the most of waste disposal capacity whilst reducing the need to develop new disposal facilities.

In this thesis, considerable attention has been paid to consideration of recycling as an activity which can complement landfill. There seems to be a new conception of recycling in the waste management sector as an opportunity rather than a source of competition. This new phenomena may be due to an increased environmental awareness of Waste Managers and their perception of potential environmental marketing opportunities. However the new professional brand of Waste Manager may also be recognising some of the economic ramifications regarding the nature of the landfill business.

Unlike most economic systems, materials move in the opposite direction to money in waste management. This means that there is less emphasis on quality of service offered, since customers only recognise legal removal of wastes as criteria on which to judge service. Once satisfied that waste removal is legal, price is the only other condition that matters (except in rare cases of environmental idealism). Consider also that landfill space is a resource as represented by Govett and Govett (Govett and

Govett 1977). In the case of landfill, however, the cost of exploiting resources is not dependent on scarcity, but on regulatory requirements.

The economics of resource management suggest that as scarcity (or in this case regulatory requirements) increases the cost of exploitation also increases, so there is more incentive to develop alternative resource streams to satisfy demand. In the case of landfill, this means finding new ways to manage the same amount (or as seems likely, increasing amounts) of waste with less exploitation of landfill space. In this context, recycling presents an excellent opportunity for waste management firms. Incineration is another option which presents similar benefits and which seems likely to become more popular in the future (especially as recent incinerator designs have overcome emission problems which have historically made them less popular).

The UK Government currently recognises that regulations imposed on waste management firms do not account for emissions arising from landfill sites.

> "the major industrial processes are required by law to employ the best practicable environmental option under integrated pollution control. However, the Government is considering what further measures, including economic instruments such as a landfill levy, are needed to apply the polluter pays principle to encourage less waste production and more recycling."
> (Department of the Environment 1994 p.15)

This statement begs the question of how such a levy should be introduced?

It seems likely that any cost increases by waste management firms will be passed on to their customers and so encourage waste minimisation and recycling which is conducted by firms other than Waste Managers (although such firms are not common place). However, given the potential role of waste management firms in developing recycling infrastructure it seems appropriate to consider how different types of levy may influence the viability of recycling activities.

In Chapter Nine it is argued that changes to capital cost only encourage recycling if firms intend to remain in the landfill business beyond the lifetime of facilities they already manage. Hence a levy on new sites opened is only likely to affect firms which stay in waste management which suggests that recycling would be promoted only in the longer term as such firms expand in the sector.

A levy on annual revenue is not likely to decrease profits of waste management firms (since prices can be increased to compensate) unless alternative forms of waste management are developed in competition with landfill. This form of levy may be successful if Waste Managers or other firms are confident enough to develop recycling facilities. Conversely it may fail if waste managers simply pass on extra costs to their customers. An alternative would be to tax the amount of waste sent to landfill sites. This approach would encourage recycling of wastes that command a low price per tonne since the value of these materials would be most radically changed.

Ideally, a landfill levy should selectively tax the materials which present the most environmental benefit if they are recycled instead of landfilled. This suggests taxing

materials that are polluting or from polluting forms of resource extraction and processing. However, this approach would be the most difficult to implement since it would involve considerable research and continued monitoring by Legislative Agencies.

In general, the regulation of landfill operations is limited by a lack of understanding of how different wastes and different practices influence pollution arising from landfill sites. This limitation makes it difficult for regulators to account for downstream effects of waste production when regulating Waste Producers and to identify appropriate process standards for waste treatment and disposal when regulating Waste Managers.

It may be that the chemistry of landfill sites is too complex to be completely modelled, but it does seem that current understanding is not as developed as it could be. This lack of knowledge may account for the fact that landfill sites are simply regulated to achieve high levels of containment. However it may be that controlled dispersal into the environment is preferable to limited containment which eventually results in the slow release of a cocktail of chemicals whose composition becomes less certain the more time elapses prior to release. Although building waste is relatively inert, consideration of chemical effects would be important when comparing recycling of reactive materials with the option to landfill them.

Research into the physical nature of landfill sites continues to attempt to resolve these problems. Such research is to be commended and findings should be considered by legislative and regulatory agencies and landfill operators at the earliest opportunity.

There may be problems associated with a lack of established recycling infrastructure for less well resourced firms to exploit. This problem may be resolved if less progressive firms are forced out of business. This would seem harsh for smaller firms that are only able to adopt abatement options and through no fault of their own, cannot locate appropriate recycling facilities and instead are forced to pay high waste management prices.

However, the UK Government may already be recognising some of the limitations of its market based approach to the polluter pays principle. Intervention in the form of a landfill levy may not of itself provide comfort to firms already worried about waste prices. However, the use of the word "levy" rather than "tax" suggests that revenue may be earmarked for spending on recycling and waste minimising options. Given the real problem of funding faced by smaller firms, this may enable those firms that can demonstrate potential improvements to environmental performance to respond to the environmental challenge currently being driven larger better resourced enterprises.

The principle of subsidy seems contrary to the UK Governments market based approach to the polluter pays principle. However, firms employ higher discount rates than governments. In Chapter Nine, it is shown that different discount rate value have a considerable effect on viability of recycling options which involve long term investments. This is a common feature of infrastructural spending in general. Governments have historically recognised a role for public finance in infrastructural projects. Some assistance for development of recycling infrastructure may be

appropriate to promote a comprehensive blend of waste options. Of course recycling should only be subsidised where it presents valueable environmental benefits, and it should not be promoted to the extent of removing incentives for waste minimisation. However, it does seem that some form of subsidy may be appropriate if recycling is to contribute significantly to environmental improvement in the UK.

In summary, although this thesis does not purport to provide exhaustive proof or disproof, it does seem from the evidence presented that current regulatory mechanisms have provided incentives for improvements to environmental performance within industry but that this may be at the expense of incentives to develop infrastructural projects such as recycling plant. The need for recycling infrastructure stems from the diverse nature of industry in the UK which includes firms that are currently unable to implement progressive Waste Policies due to resource limitations. Such firms may not be able to compete on the playing field of environmental opportunity which has evolved according to the criteria of larger enterprises. Recycling may provide a crucial alternative pathway for smaller companies to be part of the progressive league of firms.

Large industrial firms in some sectors are concerned that less progressive firms are not achieving similar environmental standards. This is not out of environmental concern but because there may be a second division of less progressive firms emerging which succeeds in exploiting; lax Local Authorities, customers concerned about price, and the strong reliance on voluntary schemes rather than regulations in some sectors. Larger firms in some sectors or local areas may lose confidence in the dynamism of the modern legislative system, unless Legislative Agencies find some way to prevent such a second division from developing into a commercial threat for more progressive firms. Subsidy of recycling options may be an easy way to improve environmental performance and maintain credibility in the dynamics of UK legislation.

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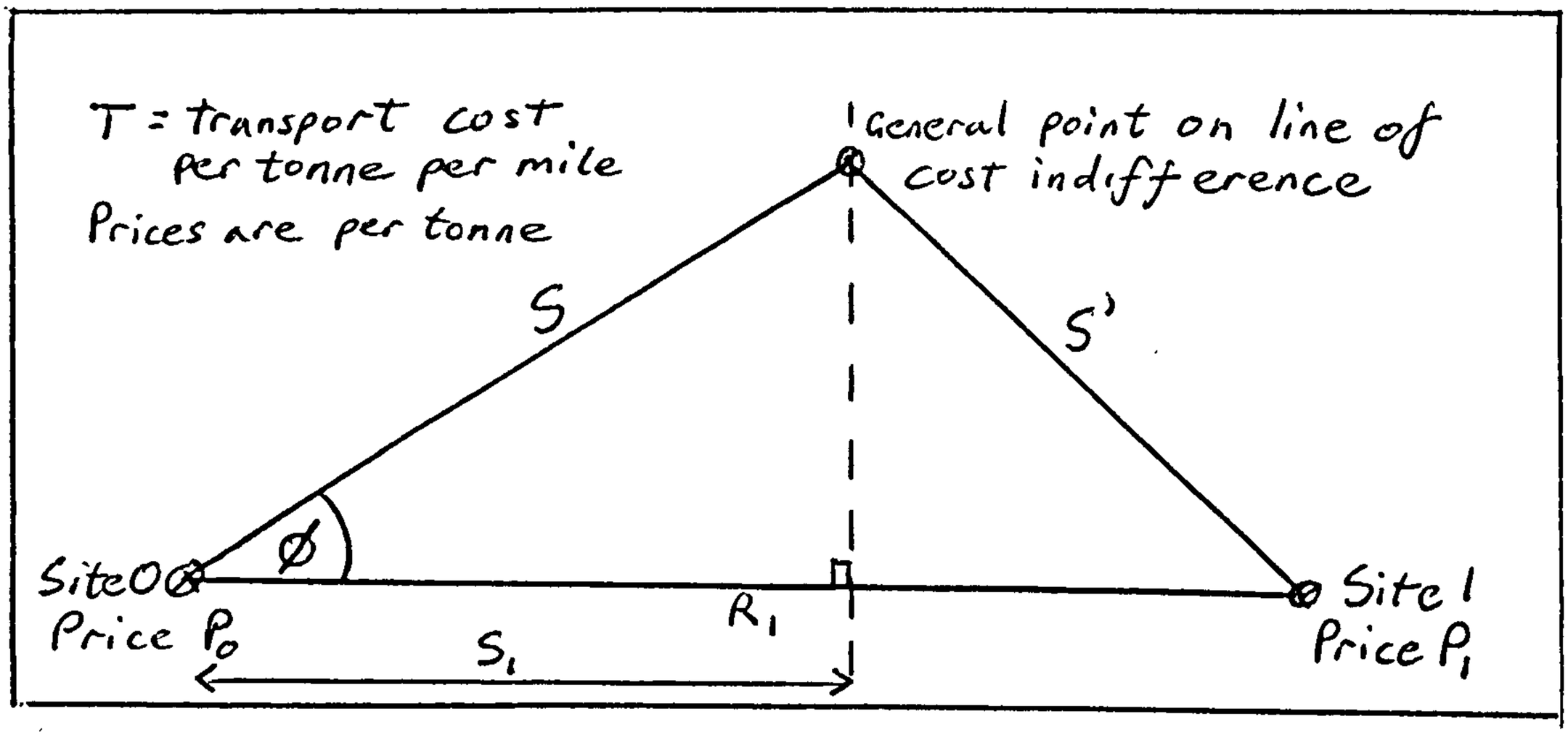
APPENDIX 1: Derivation of Equation 8.1 (p.179)

Objective - Determine perpendicular distance from Site 0 of the line of cost indifference between Site 0 and Site 1.



Cost indifference:

$$P_0 + ST = P_1 + S'T$$

$$\Rightarrow \quad S' = \frac{P_0 + ST - P_1}{T}$$

The cosine rule:

$$S'^2 = S^2 + R_1^2 - 2SR_1\cos\phi$$

$$\Rightarrow \quad \frac{(P_0 + ST - P_1)^2}{T^2} = S^2 + R_1^2 - 2SR_1\cos\phi$$

For perpendicular distance, $\phi = 0$, $\cos\phi = 1$, $S = S_1$

$$\Rightarrow \quad \frac{(P_0-P_1)^2}{T^2} + \frac{2S_1(P_0-P_1)}{T} + S_1^2 - S_1^2 - R_1^2 + 2SR_1 = 0$$

$$\Rightarrow \quad 2S_1\left(\frac{P_0-P_1}{T} + R_1\right) = \left(R_1 + \frac{(P_0-P_1)}{T}\right)\left(R_1 - \frac{(P_0-P_1)}{T}\right)$$

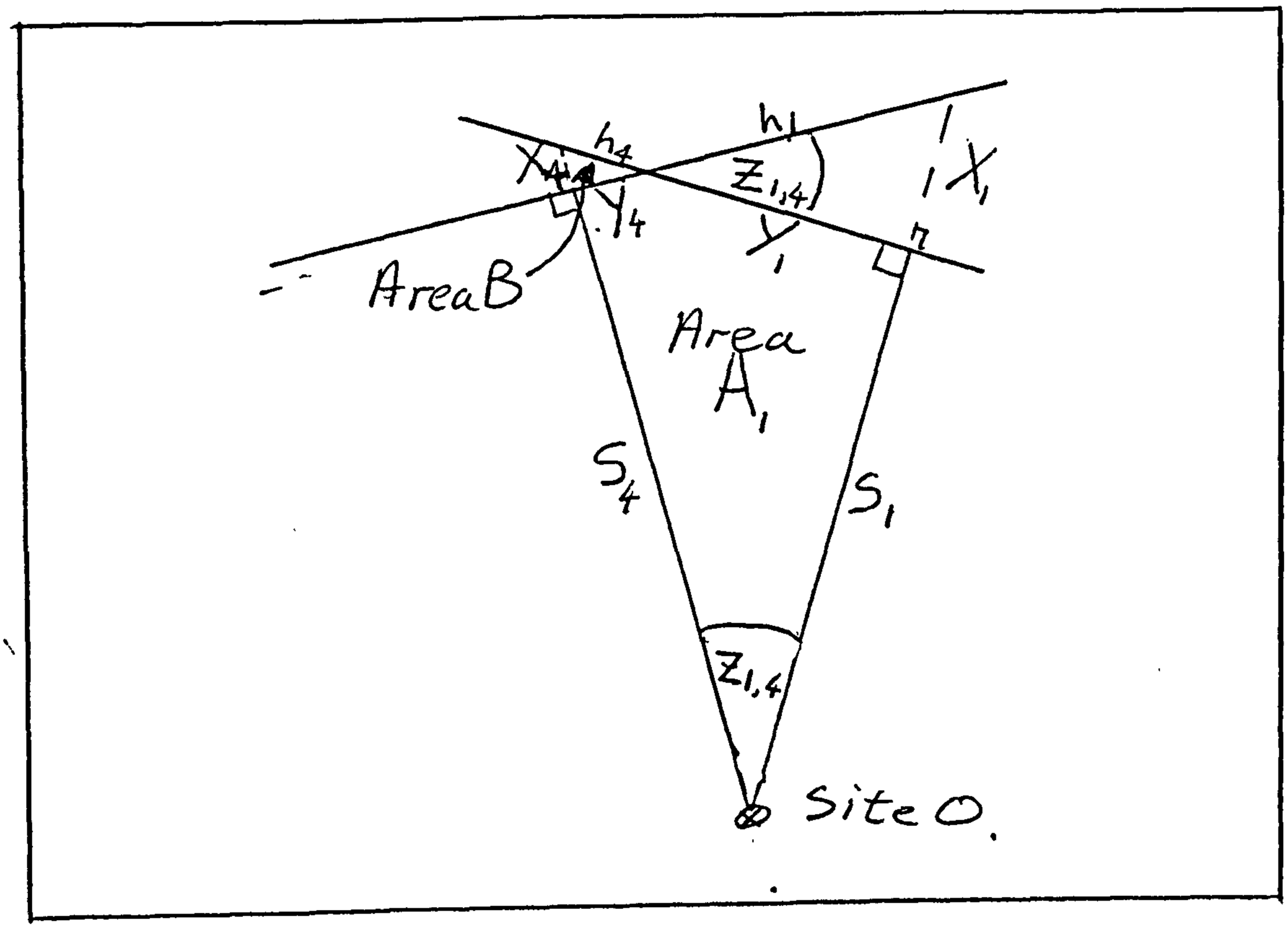
$$\Rightarrow \quad S_1 = \frac{R_1 - \frac{(P_0-P_1)}{T}}{2} \qquad \text{QED}$$

APPENDIX 2: Derivation of Equation 8.2 (p.179)

Objective - Determine contribution to catchment area due to a line of indifference.

Consider Two Cases

First Case



Now $\frac{S_1}{S_4+X_4} = \frac{S_2}{S_1+X_1} = \cos Z_{4,1}$

$\Rightarrow X_4 = \frac{S_1}{\cos Z_{4,1}} - S_4$ & $X_1 = \frac{S_4}{\cos Z_{4,1}} - S_1$

Also $X_1/h_1 = \sin Z_{4,1}$

$\Rightarrow h_1 = X_1/\sin Z_{4,1}$

Also $(h_4 + Y_1)/S_1 = \tan Z_{4,1}$ & $(h_1 + Y_4)/S_4 = \tan Z_{4,1}$

$\Rightarrow h_4 + Y_1 = S_1 \tan Z_{4,1}$ & $Y_4 = S_4 \tan Z_{4,1} - h_1$

$$\text{Area } A_1 + B = \frac{S_1(h_4 + Y_1)}{2}$$

$$= \frac{S_1^2 \tan Z_{4,1}}{2}$$

$$\text{Area } B = \frac{X_4 Y_4}{2}$$

$$= \frac{X_4(S_4 \tan Z_{4,1} - h_1)}{2}$$

$$= \frac{1}{2}\left[\frac{S_1 S_4}{\cos^2 Z_{4,1} \sin Z_{4,1}}\left(\sin^2 Z_{4,1} - 1 - \cos^2 Z_{4,1}\right) + \frac{S_4^2}{\sin Z_{4,1} \cos Z_{4,1}}\left(1 - \sin^2 Z_{4,1}\right)\right]$$

$$= \frac{1}{2}\left(\frac{S_1^2}{\sin Z_{4,1} \cos Z_{4,1}} + \frac{S_4^2 \cos Z_{4,1}}{\sin Z_{4,1}} - \frac{2 S_1 S_4}{\sin Z_{4,1}}\right)$$

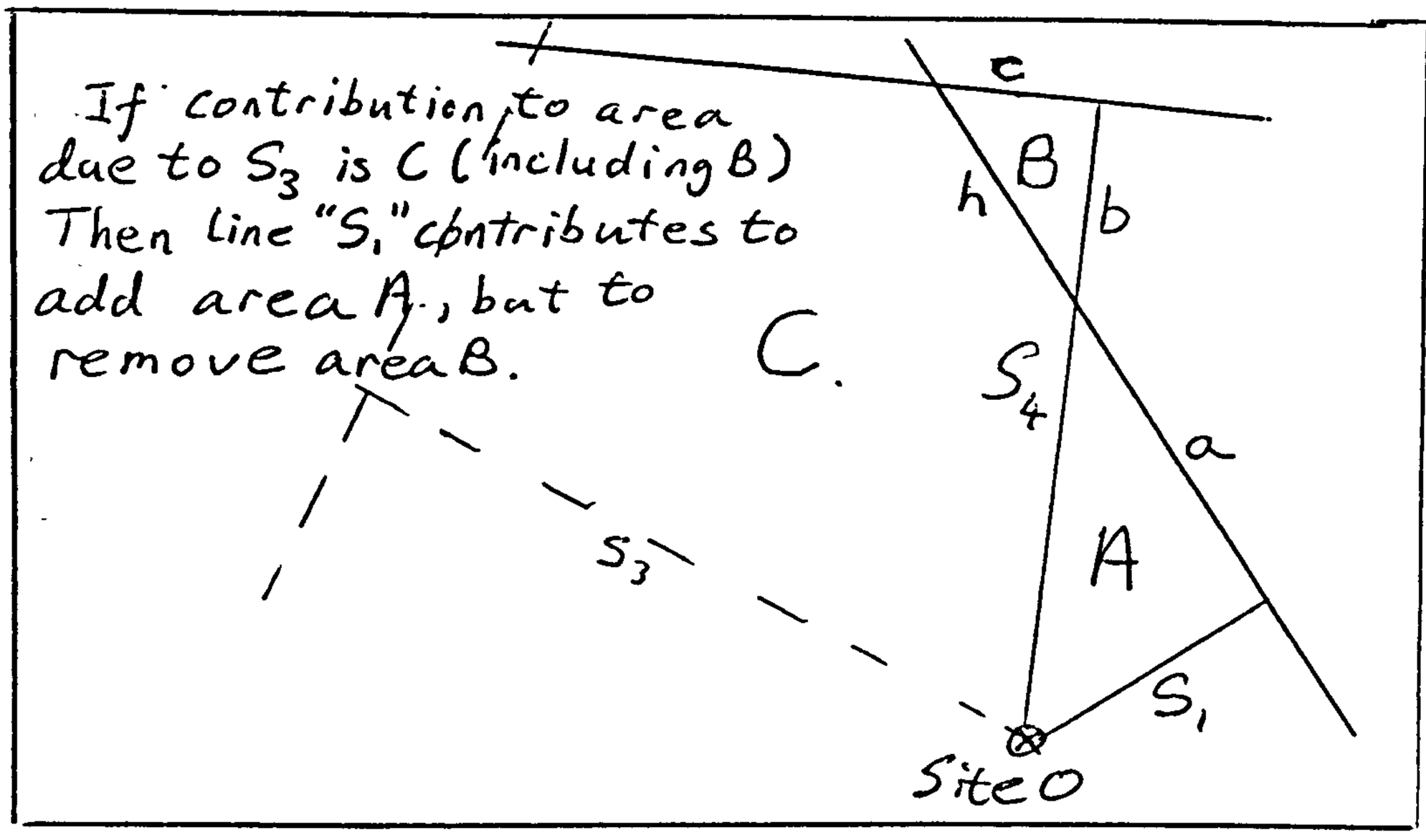
$$\text{Area } A_1 = \text{Area } A_1 + B - \text{Area } B$$

$$= \frac{1}{2}\left(S_1^2 \tan Z_{4,1} - \frac{S_1^2}{\sin Z_{4,1} \cos Z_{4,1}} - \frac{S_4^2 \cos Z_{4,1}}{\sin Z_{4,1}} + \frac{2 S_1 S_4}{\sin Z_{4,1}}\right).$$

$$= \frac{1}{2}\left(\frac{S_1^2}{\sin Z_{4,1} \cos Z_{4,1}}\left(\sin^2 Z_{4,1} - 1\right) - S_4^2 \frac{\cos Z_{4,1}}{\sin Z_{4,1}} + \frac{2 S_1 S_4}{\sin Z_{4,1}}\right)$$

$$\boxed{A_1 = \frac{1}{2 \sin Z_{4,1}}\left(2 S_1 S_4 - (S_1^2 + S_4^2) \cos Z_{4,1}\right)} \quad \underline{\text{QED.}}$$

Second case



Contribution to area ,A_1, is A-B

$$a/S_1 = b/c = \tan Z_{4,1}$$

$$\Rightarrow \quad a = S_1 \tan Z_{4,1} \qquad \& \qquad c = b/\tan Z_{4,1}$$

$$S_1/(S_4 - b) = \cos Z_{4,1}$$

$$\Rightarrow \quad b = S_4 - (S_1/\cos Z_{4,1})$$

$$\Rightarrow \quad c = (S_4/\tan Z_{4,1}) - (S_1/\tan Z_{4,1})$$

$$A_1 = (S_1 a - S_4 b)/2$$

$$\therefore \frac{1}{2}\left(S_1^2 \tan Z_{4,1} - \frac{S_4^2}{\tan Z_{4,1}} - \frac{S_1^2}{\cos Z_{4,1} \sin Z_{4,1}} + \frac{2S_1S_4}{\sin Z_{4,1}}\right)$$

$$= \frac{1}{2\sin Z_{1,4}}\left(\frac{2S_1S_4}{\sin Z_{4,1}} + S_1^2\left(\frac{\sin^2 Z_{4,1} - 1}{\cos Z_{4,1}}\right) - S_4^2 \cos Z_{4,1}\right)$$

$$\therefore A_1 = \frac{1}{2\sin Z_{4,1}}\left(\frac{2S_1S_4}{\sin Z_{4,1}} - (S_1^2 + S_4^2)\cos Z_{4,1}\right)$$

QED.

APPENDIX 3: The Spreadsheet Represented in Fig 9.2

Input Variables	(Year 0 Prices)		Inflation					
Calculated Variables			5.00%					
					Landfill Site			
Variable Name	S	T	D		KL	OL	CL	A1L
Year 0	Pit Capacity / Tonnes	Annual Throughput / Tonnes	Discount Rate		Capital Cost	Operating Cost	Restoration Cost	Aftercare 1 cost
1992	5000000	308669	20.00%	Value	£4,000,000	£750,000	£250,000	£25,000
				Annual rate	10.71%	1.76%	3.72%	5.30%
				W/o inflation	16.25%	6.85%	8.91%	10.56%
Pit lifetime	Landfill only 16				Recycling also 19			
Calculations								
NPV (year 0)			Landfill only			Restoration + Replacement		
Year	Discount	Annum	KL	OL	RL	CL	A1L	A2L
0	100.00%	1992	-£4,000,000					
1	83.33%	1993		-£636,012	£2,284,037			
2	69.44%	1994		-£539,348	£1,937,081			
3	57.87%	1995		-£457,376	£1,642,829			
4	48.23%	1996		-£387,862	£1,393,275			
5	40.19%	1997		-£328,913	£1,181,630			
6	33.49%	1998		-£278,924	£1,002,135			
7	27.91%	1999		-£236,532	£849,906			
8	23.26%	2000		-£200,583	£720,801			
9	19.38%	2001		-£170,097	£611,308			
10	16.15%	2002		-£144,245	£518,447			
11	13.46%	2003		-£122,322	£439,693			
12	11.22%	2004		-£103,731	£372,901			
13	9.35%	2005		-£87,966	£316,256			
14	7.79%	2006		-£74,596	£268,215			
15	6.49%	2007		-£63,259	£227,472			
16	5.41%	2008		-£53,644	£192,918			
17	4.51%	2009				-£20,979		
18	3.76%	2010					-£2,377	
19	3.13%	2011					-£2,086	
20	2.61%	2012					-£1,830	
21	2.17%	2013					-£1,606	
22	1.81%	2014					-£1,409	
23	1.51%	2015						-£577
24	1.26%	2016						-£509
25	1.05%	2017						-£450
26	0.87%	2018						-£397
27	0.73%	2019						-£351
28	0.61%	2020						-£310
29	0.51%	2021						-£274
30	0.42%	2022						-£242
31	0.35%	2023						-£214
32	0.29%	2024						-£189
33	0 24%	2025						-£167

34	0.20%	2026						-£147
35	0.17%	2027						-£130
36	0.14%	2028						-£115
37	0.12%	2029						-£102
38	0.10%	2030						-£90
39	0.08%	2031						-£79
40	0.07%	2032						-£70
41	0.06%	2033						-£62
42	0.05%	2034						-£55
43	0.04%	2035						-£48
44	0.03%	2036						-£43
45	0.03%	2037						-£38
46	0.02%	2038						-£33
47	0.02%	2039						-£29
48	0.02%	2040						
49	0.01%	2041						
50	0.01%	2042						
51	0.01%	2043						
52	0.01%	2044						
53	0.01%	2045						
54	0.01%	2046						
55	0.00%	2047						
56	0.00%	2048						
57	0.00%	2049						
58	0.00%	2050						
59	0.00%	2051						
60	0.00%	2052						

		Average Price per tonne				Throughput / %		
A2L	VL	PC	PH	PS	PO	TC	TH	TS
Aftercare 2 Cost	Resale Value of Land and Plant	Cover	Hardcore	Skips	Other	Cover	Hardcore	Skips
£10,000	£1,000,000	£1.00	-£1.50	£8.00	£11.00	13%	3%	20%
6.00%	4.76%	1.77%	1.77%	1.77%	1.77%			
11.30%	10.00%	6.86%	6.86%	6.86%	6.86%			
						Throughput / Tonnes		
						40126.97	9260.07	61733.8
	Total pa		Landfil extended by recycling			Restoration		
VL	T1	Annum	KL	OL	RL	CL	A1L	A2L
	-£4,000,000	1992	-£4,000,000					
	£1,648,025	1993		-£636,012	£2,284,037			
	£1,397,732	1994		-£539,348	£1,937,081			
	£1,185,453	1995		-£457,376	£1,642,829			
	£1,005,413	1996		-£387,862	£1,393,275			
	£852,717	1997		-£328,913	£1,181,630			
	£723,211	1998		-£278,924	£1,002,135			
	£613,374	1999		-£236,532	£849,906			
	£520,219	2000		-£200,583	£720,801			
	£441,211	2001		-£170,097	£611,308			
	£374,202	2002		-£144,245	£518,447			
	£317,371	2003		-£122,322	£439,693			
	£269,170	2004		-£103,731	£372,901			
	£228,290	2005		-£87,966	£316,256			
	£193,619	2006		-£74,596	£268,215			
	£164,213	2007		-£63,259	£227,472			
	£139,273	2008		-£53,644	£192,918			
	-£20,979	2009		-£45,491	£163,613			
	-£2,377	2010		-£38,577	£138,759			
	-£2,086	2011		-£32,714	£117,681			
	-£1,830	2012				-£13,548		
	-£1,606	2013					-£1,606	
	-£1,409	2014					-£1,409	
	-£577	2015					-£1,236	
	-£509	2016					-£1,085	
	-£450	2017					-£952	
	-£397	2018						-£397
	-£351	2019						-£351
	-£310	2020						-£310
	-£274	2021						-£274
	-£242	2022						-£242
	-£214	2023						-£214
	-£189	2024						-£189
	-£167	2025						-£167

	-£147	2026						-£147
	-£130	2027						-£130
	-£115	2028						-£115
	-£102	2029						-£102
	-£90	2030						-£90
	-£79	2031						-£79
	-£70	2032						-£70
	-£62	2033						-£62
	-£55	2034						-£55
	-£48	2035						-£48
	-£43	2036						-£43
	-£38	2037						-£38
	-£33	2038						-£33
	-£29	2039						-£29
£1,476	£1,476	2040						-£26
	£0	2041						-£23
	£0	2042						-£20
	£0	2043						
	£0	2044						
	£0	2045						
	£0	2046						
	£0	2047						
	£0	2048						
	£0	2049						
	£0	2050						
	£0	2051						
	£0	2052						

	Revenue		Recycling Plant				Recycling fractions	
TO	RL		KR	OR	VR		RC	RH
Other			Capital Cost	Operating Cost	Resale Value of Plant		Cover	Hardcore
64%	£2,693,137	Value	£0	£113,138	£0		50.00%	25.00%
	1.77%	Annual rate	1.90%	0.61%	1.90%			
	6.86%	W/o inflation	7.00%	5.64%	7.00%		Tonnes recycled pa	
							RC	RH
197548.2							30866.9	15433.45
					NB. max values		75000	37500
	Total pa		Recycling Plant		Revenue		Total pa	
VL	T2	Annum	KR	OR	RR	VR	T3	
	-£4,000,000	1992	£0				-£4,000,000	
	£1,648,025	1993		-£94,856	-£6,545		£1,546,624	
	£1,397,732	1994		-£79,529	-£5,550		£1,312,653	
	£1,185,453	1995		-£66,678	-£4,707		£1,114,068	
	£1,005,413	1996		-£55,904	-£3,992		£945,518	
	£852,717	1997		-£46,870	-£3,386		£802,461	
	£723,211	1998		-£39,297	-£2,871		£681,043	
	£613,374	1999		-£32,947	-£2,435		£577,992	
	£520,219	2000		-£27,623	-£2,065		£490,530	
	£441,211	2001		-£23,159	-£1,752		£416,300	
	£374,202	2002		-£19,417	-£1,486		£353,300	
	£317,371	2003		-£16,280	-£1,260		£299,831	
	£269,170	2004		-£13,649	-£1,068		£254,453	
	£228,290	2005		-£11,444	-£906		£215,941	
	£193,619	2006		-£9,594	-£769		£183,256	
	£164,213	2007		-£8,044	-£652		£155,517	
	£139,273	2008		-£6,744	-£553		£131,976	
	£118,121	2009		-£5,654	-£469		£111,998	
	£100,182	2010		-£4,741	-£398		£95,043	
	£84,967	2011		-£3,975	-£337		£80,655	
	-£13,548	2012				£0	-£13,548	
	-£1,606	2013					-£1,606	
	-£1,409	2014					-£1,409	
	-£1,236	2015					-£1,236	
	-£1,085	2016					-£1,085	
	-£952	2017					-£952	
	-£397	2018					-£397	
	-£351	2019					-£351	
	-£310	2020					-£310	
	-£274	2021					-£274	
	-£242	2022					-£242	
	-£214	2023					-£214	
	-£189	2024					-£189	
	-£167	2025					-£167	

	-£147	2026					-£147	
	-£130	2027					-£130	
	-£115	2028					-£115	
	-£102	2029					-£102	
	-£90	2030					-£90	
	-£79	2031					-£79	
	-£70	2032					-£70	
	-£62	2033					-£62	
	-£55	2034					-£55	
	-£48	2035					-£48	
	-£43	2036					-£43	
	-£38	2037					-£38	
	-£33	2038					-£33	
	-£29	2039					-£29	
	-£26	2040					-£26	
	-£23	2041					-£23	
	-£20	2042					-£20	
£982	£982	2043					£982	
	£0	2044					£0	
	£0	2045					£0	
	£0	2046					£0	
	£0	2047					£0	
	£0	2048					£0	
	£0	2049					£0	
	£0	2050					£0	
	£0	2051					£0	
	£0	2052					£0	

		Lost revenue	RR		Aftercare1	Aftercare 2	Year to start recycling
		TS*RC*PC+ TS*RH*PH for any year			A1Y	A2Y	RY
		Value	£7,717		Years	Years	
		Annual rate	1.77%		5	25	0
			6.86%				

Recycling input			
61733.8			
150000			
	Cummulative NPV		
	Landfill only	Recycling also	
	Using T1	Using T3	
Annum	CNPV1	CNPV2	
1992	-£4,000,000	-£4,000,000	
1993	-£2,351,975	-£2,453,376	
1994	-£954,243	-£1,140,723	
1995	£231,210	-£26,655	
1996	£1,236,624	£918,863	
1997	£2,089,341	£1,721,324	
1998	£2,812,552	£2,402,367	
1999	£3,425,926	£2,980,359	
2000	£3,946,145	£3,470,890	
2001	£4,387,356	£3,887,189	
2002	£4,761,558	£4,240,489	
2003	£5,078,929	£4,540,320	
2004	£5,348,099	£4,794,773	
2005	£5,576,389	£5,010,713	
2006	£5,770,008	£5,193,969	
2007	£5,934,221	£5,349,486	
2008	£6,073,495	£5,481,463	
2009	£6,052,515	£5,593,461	
2010	£6,050,138	£5,688,504	
2011	£6,048,052	£5,769,159	
2012	£6,046,222	£5,755,611	
2013	£6,044,616	£5,754,005	
2014	£6,043,207	£5,752,596	
2015	£6,042,631	£5,751,359	
2016	£6,042,121	£5,750,274	
2017	£6,041,671	£5,749,322	
2018	£6,041,274	£5,748,925	
2019	£6,040,923	£5,748,574	
2020	£6,040,613	£5,748,264	
2021	£6,040,339	£5,747,990	
2022	£6,040,097	£5,747,748	
2023	£6,039,883	£5,747,534	
2024	£6,039,694	£5,747,345	
2025	£6,039,528	£5,747,179	

Cummulative NPV difference
CNPV1 - CNPV2
£292,912

2026	£6,039,380	£5,747,031					
2027	£6,039,250	£5,746,901					
2028	£6,039,135	£5,746,786					
2029	£6,039,034	£5,746,685					
2030	£6,038,944	£5,746,595					
2031	£6,038,865	£5,746,516					
2032	£6,038,795	£5,746,446					
2033	£6,038,733	£5,746,384					
2034	£6,038,678	£5,746,329					
2035	£6,038,630	£5,746,281					
2036	£6,038,588	£5,746,239					
2037	£6,038,550	£5,746,201					
2038	£6,038,517	£5,746,168					
2039	£6,038,487	£5,746,138					
2040	£6,039,963	£5,746,112					
2041	£6,039,963	£5,746,090					
2042	£6,039,963	£5,746,069					
2043	£6,039,963	£5,747,051					
2044	£6,039,963	£5,747,051					
2045	£6,039,963	£5,747,051					
2046	£6,039,963	£5,747,051					
2047	£6,039,963	£5,747,051					
2048	£6,039,963	£5,747,051					
2049	£6,039,963	£5,747,051					
2050	£6,039,963	£5,747,051					
2051	£6,039,963	£5,747,051					
2052	£6,039,963	£5,747,051					